(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 072 770 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
31.01.2001 Bulletin 2001/05

(21) Application number: **99910748.5**

(22) Date of filing: **26.03.1999**

(51) Int. Cl.[7]: **F02B 75/26**, F02B 77/00

(86) International application number:
PCT/JP99/01595

(87) International publication number:
WO 99/54608 (28.10.1999 Gazette 1999/43)

(84) Designated Contracting States:
DE IT

(30) Priority: **16.04.1998 JP 10632198**
06.05.1998 JP 12337898
21.05.1998 JP 13908698
21.05.1998 JP 13954698

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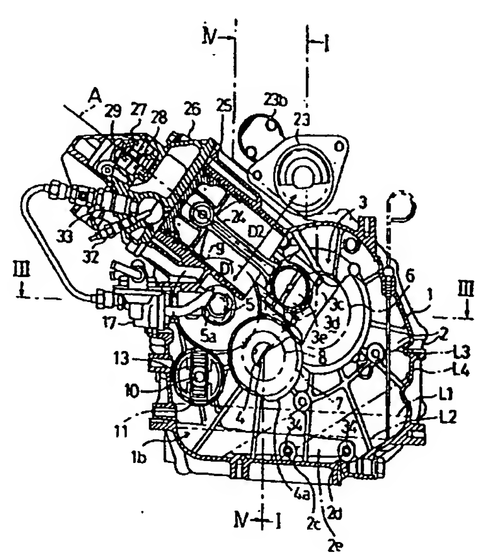
(54) INCLINED SINGLE CYLINDER ENGINE

(57) With an open one side of a crank case (1) having a single inclined cylinder unit (1c) being closed with a side cover (2), a crank shaft (3) is horizontally disposed inside the crank room units (1a, 2a) of the crank case (1) and the side cover (2) and, in positions below the axis lin A of the cylinder unit (1c), a balancer shaft (4) in parallel with the crank shaft (3), a cam shaft (5), a lubricating oil pump drive shaft (doubling as a governaor drive shaft) (10) and a cooling water pump drive shaft (20) are disposed with the two shaft (10, 20) disposed on the same axis. A crank gear (6) is porvided to one side portion of the crank shaft (3), a first balancer gear (7) out of the first balancer gear (7) and a second balancer gear (8) which are kept connected with the balancer shaft (4) meshes with a crank gear (6) and a second balancer gear (8) meshes with a cam gear (9) on the cam shaft (5). The cam gear (9) gear-meshes with the cooling water pump drive shaft (20) and a third balancer gear (19) provided on the portion opposite to the first and second balancer gears (7, 8) on the balancer shaft (4) gear-meshes with the lubricating oil pump drive shaft (10).

FIG. 5



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Description

Field of the Art

[0001] The present invention relates to a novel and improved single inclined cylinder (water-cooled) engine having a crank case integrally forming a inclined cylinder, wherein various rotating shafts and various devices driven by the rotating shafts to be supported in the crank case or in a side cover which covers the crank case are rearranged so as to compact the engine, especially to lower the top of the engine, the structure of lubricating oil passages is improved to reduce the manufacturing cost of the engine, the structure of an output shaft is improved to make the engine possible to drive a plurality of loads which are common in rotational direction, and a radiator, a fuel tank, a muffler and the like surrounding the water-cooled engine body are rearranged compactly to enhance the cooling efficiency without sacrificing the capacities of the fuel tank and the radiator.

Background Art

[0002] Conventionally, there has been a well-known single cylinder engine such as disclosed in Japanese Utility Model Publication No. hei 5-45876, wherein an axis of a cylinder is inclined from the vertical when a crank shaft is disposed horizontally.

[0003] It is needless to say that such a inclined cylinder takes an advantage in vertically compacting the engine (reduction of the height of the engine). Furthermore, the prior single cylinder engine was provided with a balancer shaft engaging with the crank shaft through gears, or a reciprocally movable balancer, as disclosed in the above cited document, which countered the vibration caused by the rotation of the crank shaft . Such balancing means were disposed just under the crank shaft , so that they were soaked in lubricating oil in the oil pan formed by the inner bottom of the crank case, and agitated the oil according to their rotation, thereby raising the temperature of the lubricating oil. Also, the balancing means were decelerated in their rotation or were strained by the resistance of agitated oil. If the single cylinder is disposed slantwise, such balancing means disposed on an extension of the axis of the cylinder crossing the crank shaft become higher sufficiently apart from the bottom of the crank case so as to be disposed above the lubricating oil sump without sinking therein. This is another reason for that the single cylinder is slanted.

[0004] In the crank case, besides the crank shaft and the abovesaid balancer shaft (hereinafter, the balancer shaft may be replaced with the reciprocally movable balancer), at least a cam shaft for driving inlet and exhaust valves and a fuel injection pump (of a diesel engine) or another device are disposed. Conventionally, the cam shaft has directly engaged with the crank shaft through gears.

[0005] However, there must be a certain distance between the crank shaft and the cam shaft for ensuring the rotational range of crank arms and balance weights of the crank shaft and the speed reduction ratio between both the shafts. Therefore, a gear provided on the cam shaft (hereinafter named as a cam gear) for engaging with the crank shaft has been diametrically large. Accordingly, when the cam shaft is to be disposed below the cylinder, the problem arises that the inclined cylinder must be nearly vertical, defying the purpose of its slanting (for vertically compacting the engine and for higher positioning the balancer shaft).

[0006] Additionally, a space for the balancer shaft must be provided in opposite to the earn shaft about the crank shaft . When the inclined cylinder is provided nearly horizontally so as to lower the top of the engine, the conventional crank case, which has contained the balancer shaft disposed on the extension of the axis of the cylinder, comes to be expanded in the opposite side to the cylinder. Therefore, it is preferable that the balancer shaft is offset upwardly or downwardly from the extension of the axis of the cylinder while they can effectively counter the vibration of the crank shaft . However, when it is offset upwardly therefrom, in other words, beside the cylinder, the upper dimension of the crank case must be large, defying the requirement for its compacting. Additionally, it is preferable that a starter motor is disposed beside the cylinder without projecting outwardly. When the balancer shaft is disposed there, it comes to be impossible.

[0007] Furthermore, various devices like a governor, a lubricating oil pump and a cooling water pump must be driven by use of the rotation of the crank shaft . The cam shaft or the balancer shaft, if it serves as a driving shaft for one of the devices, has to be lengthened, thereby wrongly elongating the engine sidewise.

[0008] Referring to a governor, a swinging fulcrum of a governor lever, which is connected with a regulator of a fuel injection pump, has been located at the middle position between the fuel injection pump driven by the cam shaft and a centrifugal governor weight provided around a governor driving shaft engaging with the cam shaft through gears. Thus, when the governor lever is vertically disposed, the swinging fulcrum comes to an intermediate portion of the governor lever, so that the upper and lower ends of the governor lever become free ends, while the upper end is connected with the regulator, and the lower end with the movable portion of the governor weight. Accordingly, the position of the governor driving shaft must be lowered so far as to ensure a long stroke of the governor. If the gear on such a low governor driving shaft, which engages with the gear of the cam shaft) is sunk in the lubricating oil sump (oil pan), there arises the same problem as the above. Considering the gear to be disposed above the lubricating oil sump, as a result the hight of engine must be tall.

[0009] Then, suppose that the governor driving shaft is the same of the balancer shaft or engages with

the balancer shaft through gears, and the cam shaft is disposed below the cylinder, the conventional governor has been disposed beside the cylinder in opposite to the cam shaft according to the position of the balancer shaft. If the balancer shaft is separate from the governor driving shaft and the both shafts engage with each other through gears, the starter motor cannot be disposed in the space beside the cylinder. It must be disposed at another place in wrong projecting formation. If the balancer shaft is the same of the balancer shaft, the balancer shaft must be lengthened, thereby excessively elongating the engine in horizontal.

[0010] For the next point, there has been a well-known engine which has a crank case opening at its one side, and a side cover provided onto the opening side of the crank case. The crank room in the crank case is formed at its bottom into an oil pan for lubrication, and a lubricating oil passage in communication with the oil pan is bored within the wall of the crank case or the side cover.

[0011] A inclined cylinder engine is often settled slantwise (tilted), whereby the cylinder varies its axial direction with respect to the vertical or the horizontal. Accordingly, the oil surface of the oil pan changes its angle from the axis of the cylinder. If the inclined cylinder engine has such a side cover as the above, a lubricating oil inlet in connection with the lubricating oil passage is open at a side wall of the crank case of the side cover so as to lace the oil pan. Conventionally, there has been provided only a single of the oil inlet out of consideration of the tilt angle of the settled engine, whereby, if the engine is tilted, the structure of the oil pan and the position of the lubricating oil inlet and passage have required to be changed according to the angle of the tilted engine, thereby increasing the manufacturing cost of the engine.

[0012] Furthermore, the crank case or the side cover, which is provided at its circumference with various devices such as a fuel injection pump and a fuel feed pump, have been bored by holes for making portions of the devices pass therethrough. If the holes were parallel, the boring cost thereof would be reduced and the maintenance of the devices would be easy. A lubricating oil filter is often provided onto the outward opening of the lubricating oil passage. If the holes were parallel to the lubricating oil passage, the lubricating oil filter, the fuel injection pump and the fuel feed pump would be provided on the same side in parallel, whereby the maintenance of them all could be performed easily and simultaneously. However, in fact, the conventional lubricating oil passage and holes for the devices have never been bored on such a viewpoint, thereby increasing the manufacturing cost thereof. The resulting devices have been out of utility about their positions and complicated their maintenance.

[0013] Conventionally, it has been well-known that a relief valve is disposed at a lowerstream portion of the lubricating oil passage for regulating the pressure of lubricating oil discharged from the lubricating oil pump, when the pump is provided on the crank case or the side cover for feeding the above-mentioned lubricating oil passage with lubricating oil. However, the relief valve has been limited about its position, so that it could not exactly regulate the lubricating oil pressure in the foremost end of the lubricating oil passage. On the other hand, a lubricating oil passage toward the cam shaft has been exclusively bored in the bearing for the cam shaft or in the cam shaft, thereby having disadvantages in the number of processes for its manufacture and the strength of the bearing or the cam shaft.

[0014] For the next point, the conventional single inclined cylinder engine having the above-mentioned side cover has been provided with a flywheel on its crank shaft at the outside of the crank case in opposite to the side case. The power of the engine can be taken out from one of the ends of the crank shaft , whether it is on the same side with the flywheel or opposite to the flywheel, or both of them.

[0015] When the engine power can be taken out from both ends of the crank shaft , two loads can be driven by the sole engine, simultaneously. However, the input rotations of both the loads connected with the respective ends of the crank shaft without reversing are rotated in relatively opposite directions to each other. Accordingly, it is impossible that a pair of oneway-rotatable loads in common about the input rotary direction are simultaneously driven by the engine. In the case that the both loads, when their output members are disposed in parallel, are to be common in their output rotational directions, the output rotational direction of one of the loads must agree with the input rotational direction thereof, while the output rotational direction of the other load being opposite to the input direction thereof. If the input shaft of the load is reversible and its output shaft is reversed following the reversing of the input shaft, a pair of the loads must be provided on the assumption that the output rotary directions of the both loads are relatively opposite to each other. Thus, the number of application models, wherein a pair of loads are driven by the sole single inclined cylinder unit engine, has been limited. Even if one of the models is performed, the loads must be modified or the output rotation of one load must be reversed, excepting the case that the output rotations of both loads are allowed to be opposite to each other.

[0016] If such a power-take-out portion which rotates oppositely to the rotary direction of the crank shaft can be provided on a side of the engine, a pair of oneway-rotatable loads can be driven by the sole engine, simultaneously. Even if one load only is driven by the engine at one side thereof, either side of the engine, which is the same with or opposite to the flywheel, must be selected for the power taking out corresponding to various situations. If a oneway-rotatable load can be drivingly connected with the power-take-out portion whether it is disposed on the same side with or

the opposite side to the flywheel, the load requires no modification, thereby saving the cost for it.

[0017] However, if the power-take-out portion is constituted by the crank shaft, for enabling a pair of one-way-rotatable loads provided on both sides of the engine, the crank shaft must be divided into two portions rotated in opposite to each other, one of the two being integral with the flywheel, thereby being complicated and expensive. Furthermore, the cam shaft and many parts such as a lubricating oil pump and a cooling water pump must be made to correspond either of the two divided portions of the crank shaft, thereby further causing the increase of cost.

[0018] Besides, when the engine power is taken out from the crank shaft on the same side of the engine with the flywheel, a flywheel housing, which is separate from the crank case, has optionally been provided on the crank case, and a load to be directly connected with the power-take-out portion of the engine has been attached to the flywheel housing. The flywheel housing to be attached to the crank case requires bolts for strong clamping and pins or grooves for positioning, thereby increasing the number of parts and the cost and weight of the engine.

[0019] For another point, a water-cooled engine having a single horizontal cylinder was provided above its cylinder with a vertical radiator. A cooling fan disposed in front of the radiator was drivingly connected with a rotary shaft like a crank shaft through an endless belt, thereby making the entire engine excessively tall. Additionally, there was a problem about the durability of the endless belt. In case that the belt were damaged, the radiator could not be operated, thereby overheating the engine.

[0020] For solving the above problem, conventionally, there has been such an art, as shown in Japanese Utility Model Laid Open Gazette No. Sho 57-2209, that a radiator is horizontally above the horizontal cylinder, a cooling fan is separated from the radiator and attached to a flywheel to use the centrifugal force of the flywheel, and a covering member is disposed above the flywheel for guiding the cooling wind between the cooling fan provided on the flywheel and the radiator. In the same is shown the arrangement of various parts such as a fuel tank and a muffler on the circumference of the engine.

[0021] Referring to the cited art, the radiator is disposed substantially as high as the upper portion of the cooling fan. The cooling air blown from the cooling fan flows through a substantially horizontal fan case between the upper portions of the cooling fan and the upper portion of the radiator.

[0022] The fuel tank is disposed substantially horizontally above the radiator. The muffler is disposed outside the side of engine toward the cylinder head, so as to project further outwardly than the cylinder head.

[0023] The conventional arrangement of such parts surrounding the engine will be checked with the requirements for compacting the water-cooled single cylinder engine. Referring to the former horizontal cylinder engine, there was only a narrow space between the top of the cylinder and the lower surface of the radiator for permitting the cooling wind pass toward the radiator. To ensuring the more quantity of cooling wind for the radiator, a cover portion above the cooling fan and the radiator was expanded upwardly, thereby complicating its form, so as to increase the manufacturing cost of the covering member.

[0024] The conventional engine has been vertically elongated against the requirement for compacting due to the fuel tank disposed above the radiator. Furthermore, since the fuel tank in a horizontally elongated shape has been disposed substantially horizontally, when the fuel surface in the fuel tank is inclined in the case such that the engine was settled slantwise, the fuel surface lowered according to the consumption of fuel comes lower than the fuel outlet of the fuel tank for a short time, thereby increasing the frequency of aeration, which causes the output deterioration of the engine, and increasing the frequency of refueling while a rather much quantity of fuel remaining in the fuel tank.

[0025] The conventional muffler has projected outwardly sidewise against the requirement for horizontally compacting an engine.

[0026] Referring to the cited conventional engine in the viewpoint of the efficiency of cooling the crank case and the cylinder, the cooling wind from the cooling fan has flown along the fan case disposed above the cooling fan and the flywheel toward the radiator disposed above the crank case and the cylinder, so that there has been short of the cooling wind blown against the crank case and the cylinder. In other words, the cooling air from the cooling fan has not been used for cooling the crank case and the cylinder sufficiently.

[0027] Additionally, a fuel tank filled of fuel naturally has a cooling effect to the surroundings. However, the conventional fuel tank disposed above the radiator has not been able to be used enough to cool other members. On the contrary, it has been feared that the fuel tank is heated by the air exhausted from the radiator.

[0028] The conventional horizontally elongated fuel tank disposed substantially horizontally has been screwed in at a side end of its vertical center portion, or fixed at its upper and lower ends sidewise. It is desired that a fuel tank and a radiator are supported simply and steadily with as few parts as possible while ensuring their enough capacity. However, the taller the fuel tank is, the stronger the fixture for it is required.

[0029] If a vertically elongated fuel tank is supported on a side surface of the crank case, the space above the crank case will be no use for disposal of a fuel tank, thereby vertically shortening the engine. If the fuel tank is also supported at its upper and lower portions, its supporting will be stead. However, since the side surface of the crank case vibrates according to the rotation of the crank shaft, the fuel tank must be vibro-isolated.

[0030] The radiator has not been entirely covered

because of the fuel tank disposed thereabove, and has been directly attached to the crank case as an engine body, against the requirement for shielding the noise caused by the vibration of the engine body (the crank case) and the radiator.

Summary of the Invention

[0031] The present invention relates to a single inclined cylinder unit type engine having a crank case which is provided therein with a horizontal crank shaft, and thereon with a inclined cylinder. The first object of the present invention is to compact the engine entirely while the engine being provided with various devices such as a lubricating oil pump and a governor.

[0032] To attain the first object, at least axes of a balancer shaft and a can shaft as rotary shafts in parallel to the crank shalt are disposed below an axis of said cylinder. Accordingly, an upper portion of the crank case above the axis of the cylinder, where the balancer shaft and the cam shaft do not exist, can be saved, so that various kinds of equipments like a starter motor can be disposed above the top of the crank case.

[0033] In the vicinity of one side ends of the group of the rotary shafts in the crank case are disposed a crank gear fixed on the crank shaft, a cam gear fixed on the cam shaft, a first balancer gear fixed on the balancer shaft, and a small second balancer gear fixed on the same shaft in adjacent to the first balancer gear. The first balancer gear engages with the crank gear, and the second balancer gear with the cam gear. Due to such a gear train of the crank gear, the first balancer gear, the second balancer gear and the cam gear, the rotation of the crank shaft is transmitted to the cam shaft through the balancer shaft.

[0034] If the cam gear directly engaged with the crank gear, the cam gear would have to be large because of the large radius of gyration of crank arms and balance weights of the crank shaft , so that the distance between the crank shaft and the balancer shaft would have to be enlarged. Regarding to the present invention as the above said, the radius of gyration of the balancer gear is small and the the second balancer gear engaging with the cam gear is diametrically smaller than the first balancer gear engaging with the crank gear, so that the can gear and the first balancer gear overlap when viewed along their axes. Also, the cam gear does not have to be greatly large for ensuring the sufficient speed reduction, whereby the distance between the cam shaft and the balancer shaft can be short. The largest radial of gyration of the balancer shaft overlaps with that of the crank shaft, so that the crank shaft, balancer shaft and cam shaft of the rotary shaft group can be collected in a small space. Accordingly, a lower portion of the crank case below the inclined cylinder does not have to be upwardly enlarged for arranging the balancer shaft and the cam shaft. As a result, the angle of the inclined cylinder from the horizontal surface comes to be rather small, then the entire engine can be vertically short.

[0035] A lubricating oil pump having a lubricating oil pump drive shaft in parallel to the group of rotary shafts is disposed in the vicinity of the one side ends of the group of rotary shafts. The lubricating oil pump drive shaft engages with said cam gear. A third balancer gear is fixedly provided on said balancer shaft in the vicinity of the other side end thereof. A cooling water pump having a cooling water pump drive shaft in parallel to said group of rotary shafts is disposed in the vicinity of the other side ends of said group of rotary shafts. The cooling water pump drive shaft engages with said third balancer gear.

[0036] Accordingly, for the first effect, the lubricating oil pump and the cooling water pump can be disposed adjacently to the cam shaft and the balancer shaft due to their engaging with the shafts. The cam shaft and balancer shaft, when the pumps are disposed co-axially with the respective shafts, can be prevented from excessive extension. For the second effect, due to both of the pumps separated on both sides of the rotary shaft group in the crank case, the pumps can be juxtaposed in the condition that the driving shafts of the pumps are disposed co-axially with each other, thereby saving the extension of the crank case. For the third effect, there can be provided a space for compact arrangement of a governor lever, as discussed below, between both the pumps.

[0037] In the crank case, a centrifugal governor weight is provided around the lubricating pump drive shaft. A governor lever rotated by the action of the centrifugal governor weight is vertically disposed between the centrifugal governor weight and the cooling water pump in the crank case. A fuel injection pump having a member for adjusting a quantity of injected fuel. The member is connected with an upper free end of the governor lever. A fulcrum of the governor lever is disposed below the lubricating oil pump drive shaft.

[0038] Accordingly, for the first effect, the dead space between the pumps can be used for location of the governor lever, thereby compacting the engine. For the second, the governor lever, when the governor lever is to be extended for fine adjusting of the quantity of injected fuel, requires not the lubricating oil pump drive shaft but only the fulcrum to be lowered. Thus, the governor can be resistant against hunting or other problems while the gear provided on the lubricating pump drive shaft (for driving both the lubricating oil pump and the governor) does not sink in the lubricating oil sump in the bottom of the crank case.

[0039] Furthermore, at least axes of a balancer shaft, a cam shaft and a governor driving shaft as rotary shafts in parallel to the crank shaft are disposed below an axis of said cylinder. Accordingly, the balancer shaft, the cam shaft and the governor with the governor driving shaft do not exist above the axis of the cylinder, so that the upper end portion of the crank case can be

saved, whereby various kinds of equipments like a starter motor can be compactly disposed close to the inclined cylinder above the crank case. Even if the axis of the cylinder is nearly vertical according to the positioning of the engine, the equipment beside the cylinder does not project horizontally, whereby the engine is kept compact.

[0040] The second object of the present invention, regarding to a single inclined cylinder unit which is so constructed that a crank case is open at its one side and closed by a side cover and a horizontal crank shaft is disposed through a crank room formed in the crank case and the side cover so as to be journalled by the walls of the crank case and the side cover, is to provide a simple and cheep passage structure for lubricating oil while keeping effective lubrication.

[0041] To attain the second object, a lubricating oil passage is formed within a wall of either the crank case or the side cover. A plurality of lubricating oil inlet ports connecting with the lubricating oil passage are open at the side surface of the oil pan constituted by either the crank case or the side cover. At least one of the plurality of lubricating oil inlet ports can be chosen in correspondence to the angle of the inclined cylinder from the vertical when the engine is mounted. The resulting engine does not require an alternative lubricating oil inlet and suction means corresponding to its mounting angle. Accordingly, the engine, however slantwise it may be mounted, can be regularly lubricated through the lubricating oil passage. Such a generally correspondent engine can reduce the complexity of its mounting and the most suitable one of the lubricating oil inlets can be chosen according to the situation of its location.

[0042] The same engine is additionally provided in the crank room thereof with a cam shaft in parallel to the crank shaft. A lubrication hole is bored in either the crank case or the side cover for supplying the crank shaft with lubricating oil, and attaching holes are bored in either the crank case or the side cover for attaching a fuel injection pump and a fuel feed pump thereto. The lubrication hole and the attaching holes are in parallel and cross an axis of the cam shaft or an extension of the axis. Accordingly, the set of holes can be easily bored. The fuel feed pump, the fuel injection pump and an optional lubricating oil filter to be disposed onto the opening of the lubricating oil passage can be easily attached to the same side of the engine with substantially the same height at one process.

[0043] Additionally, a lubricating oil pump is provided on either the crank case or the side cover. An oil hole is bored in either the crank case or the side cover, so as to be connected with a discharge port of the lubricating oil pump. A pressure relief hole branches from the oil hole and is open toward the vicinity of a journal portion of the cam shaft. Such a construction can regulate the pressure in the lubricating oil passage simply and also can be used for lubrication of the cam shaft simply without another private oil passage, thereby saving the number of processes and cost for manufacturing the lubrication system for the cam shaft.

[0044] As a result, the single inclined cylinder unit engine can be greatly lubricated by use of such a simple and cheep lubrication system for the crank room formed by the crank case and the side cover.

[0045] The third object of the present invention, regarding to a single inclined cylinder unit engine having a flywheel on one side ends of its crank shaft, is to enable a one-way directed load to be driven whichever side of the engine it is provided on, and is to ease the flywheel to be provided onto the crank shaft while being certainly retained.

[0046] To attain the third object, the crank gear fixed on the crank shaft directly engages with the balancer gear fixed on the balancer shaft, and one end of the balancer shaft in opposite to the flywheel projects outwardly from the engine body. The sole engine can drive a pair of loads, whose rotary directions are in common, on its both sides without a model change of the load or complex separation of the crank shaft, thereby enhancing the usage of the single inclined cylinder unit engine and saving its cost. If the engine power is to be taken out from either side of the engine between the flywheel and the side cover, almost all component parts can be still used in common except of the flywheel and the balancer shaft. Thus, the single inclined cylinder unit engine can be changed between both types, which are different from each other in their power-take-out sides, so that it can be correspondent to various needs at low cost.

[0047] Additionally, the flywheel is provided on one end of the crank shaft adjacently to said side cover, and a flywheel housing containing said flywheel is integrally formed by the side cover. A conventional flywheel housing separated from the side cover, when being attached to the crank case, has required some parts like bolts for its fixing and a pin or a groove for its location. The flywheel housing of the present invention does not need such parts, thereby saving the number of parts and the cost thereof. Also, the engine can be lightened because the increase of weight caused by attaching of the flywheel is limited. Simply and compactly the flywheel housing can be formed into various kinds of shape by the side cover, and, if necessary, removed therefrom, in comparison with the case that it is formed by the crank case. It can be formed by die casting, thereby reducing its manufacturing cost.

[0048] The fourth object of the present invention regarding to a water-cooled single inclined cylinder unit is to keep the engine compact while effectively providing various surrounding devices on the engine, and to obtain enough cooling effect.

[0049] To attain the fourth object, a cooling fan is disposed on one end of the crank shaft. A radiator is disposed substantially horizontally above the inclined cylinder and the crank case when the crank shaft is

disposed horizontally. A fan case is disposed on the one end of the crank shaft for covering the cooling fan. The fan case is disposed substantially vertically between the cooling fan and the radiator, and constitutes at its interior a volute guide for introducing the cooling wind from the whole of area surrounding the cooling fan. The radiator is vertically shorter than a vertically disposed radiator. The cooling fan disposed on one end of the crank shaft for blowing the cooling air into the radiator is directly rotated by the crank shaft without additional transmission system like an endless belt, thereby saving the number and cost of parts for driving the cooling fan. The space between the upper portion of the cylinder and the upper portion of the crank case can be used as an passage for enough quantity of cooling wind toward the lower surface of the radiator. The space is expanded upwardly according to the slanting of the cylinder. Even if a starter motor is disposed in the space (or on the top of the crank case) for entirely compacting the engine, there remains an enough space above the starter motor. Accordingly, the radiator, if it is disposed so as to face the remaining space, has a capacity enough to cool the engine and is lowered. The vertical fan case between the cooling fan and the radiator has a sharp appearance and a simple shape so as to reduce its manufacturing cost. The wind from the whole surrounding of the cooling fan into the radiator, while passing through the volute guide formed by the fan case into the radiator, blows against not only the top but also the side ends and the bottom of the front or rear surface of the crank case facing the cooling fan, thereby cooling the crank case further effectively.

[0050] The water-cooled single inclined cylinder unit engine is provided with a vertically elongated fuel tank disposed along the outside surface of the crank case in opposite to the inclined cylinder when viewed along the crank shaft. In addition to some above-mentioned effects, the engine is vertically compact because the fuel tank does not exist above the radiator. The vertically elongated fuel tank, which is disposed at the vacant space beside the crank case without the cylinder, has a sufficient capacity. Even if the fuel tank is disposed vertically slantwise, the fuel outlet of the fuel tank is kept below the fuel surface in the tank, thereby avoiding aeration. The fuel tank does not have to be fed with fuel until it becomes nearly empty, thereby saving waste refueling. Conversely, the space above the crank case can be ensured for substantially horizontally extending the radiator thereabove because the fuel tank is vertically extended on the side surface of the crank case. While an electrical equipment like a starter motor is disposed above the crank case, the fuel tank on the side surface of the crank case is offset from the electrical equipment, so that, even if a fuel leak is generated on refueling, the electric equipment is apart from the leaky fuel tank. Furthermore, the engine is sound isolated due to the fuel tank entirely covering the crank case and the side cover in opposite to the cylinder. If the group of rotary shafts including the balancer shaft and the cam shaft excepting the crank shaft are disposed below the inclined cylinder, the area of the crank room in opposite to the cylinder about the crank shaft becomes vacant, so that the portion of crank case and the side cover surrounding the area can be compacted, along which the fuel tank is disposed with a large capacity. If the surface of the fuel tank coincides the shape of the side surface of the crank case and side cover facing the fuel tank, the fuel tank can be extended into the recessed bottom portion of the side surface of the crank case and side cover, thereby further enhancing the volume of the fuel tank.

[0051] Further regarding to the water-cooled single inclined cylinder engine having such a fuel tank, the fan case is partly cut away so as to provide an opening, and a part of the fuel tank is disposed along the opening, so that the fan case and the part of the fuel tank constitute a volute guide for guiding the cooling wind from the cooling fan to the radiator. In additional to the aforesaid effects, a part of the wall of the fuel tank is extended to the opening of the fan case without consideration of the gap between the fuel tank and the fan case, thereby increasing the volume of' the fuel tank while keeping its compact form. The fuel tank is blown by the cooling fan so as to be efficiently cooled because a part of its wall constitutes a part of the volute guide. Additionally, due to the vertically elongated fuel tank disposed along the outer surface of' the crank case, the crank case also may be effectively cooled. The opening can be provided simply by the mere cutting of the fan case.

[0052] A cap provided on a refueling opening of the fuel tank is disposed above the radiator. In addition to the above effects, refueling can be easy. Due to such upwardly projecting refueling opening, the fuel tank, even if it is mounted vertically slantwise so as to slant the fuel surface, can be prevented from a fuel leak from the refueling opening when refueling, and also, the top of the fuel tank can be high, thereby increasing the volume thereof.

[0053] Regarding to the same water-cooled single inclined cylinder unit engine, a foot member is fixed on a side surface of the crank case. A lower portion of' the fuel tank is attached to either the crank case or the foot member through a vibration isolator. An engaging member is erected on said crank case. An upper portion of the fuel tank engages with the engaging member, and a vibration isolator is interposed between the upper portion of the fuel tank and the engaging member. Since the vertical fuel tank on the side surface of the crank case is supported at its upper and lower portions, even if it has a large capacity, simple and cheep supporting members, which is not greatly strong, are enough to support the fuel tank certainly. Since the vibration isolators are used as the upper and lower supporting members, the vibration of the crank case extends little to the fuel tank, thereby preventing fuel in the fuel tank from vibration. If the engaging member is also used for supporting the radiator and the radiator cover, the number

and cost of parts can be saved and the engine can be compacted.

[0054] The above-said water-cooled single inclined cylinder engine is further provided with a radiator cover continuously connected with the fan case, thereby excluding the noise from the radiator. The radiator cover also acts as a cooling wind duct, whereby the whole of cooling wind from the fan case can be certainly guided into the radiator without escape, thereby improving the heat exchange through the radiator so as to ensure the cooling effect as much as the capacity of the radiator.

[0055] Regarding to the abovesaid water-cooled single inclined cylinder engine, the space above a cylinder head, which is suitable for heat dissipation, can be provided for the muffler. The space is also beside the radiator, so that the muffler does not project upwardly from the radiator, thereby causing the engine vertically compact, while ensuring a sufficient capacity of the muffler. Also, an air cleaner can be disposed below the muffler on a side of the fan case, so as not to project sidewise.

[0056] Due to such arrangement of various equipments surrounding the water-cooled single inclined cylinder unit engine, the engine can be entirely compact and be reduced in its cost while ensuring the abilities of the equipments (such as an enough volume, a great effect of cooling and a great effect of sound isolation).

Brief Description of the Drawings

[0057]

Fig. 1 is a front view of a single inclined cylinder engine according to the present invention having a crank room formed by a crank case 1 integrally provided with a cylinder and covered at its rear opening with a side cover 2, in other words, when viewed in a side opposite to side cover 2, wherein a flywheel is disposed on a side of side cover 2;

Fig. 2 is a rear view of the same, that is, when viewed in the same side with side cover 2;

Fig. 3 is a right side view of the same, that is, when viewed in a side opposite to the cylinder;

Fig. 4 is a left side view of' the same, that is, when viewed in the same side with the cylinder;

Fig. 5 is a sectional front view of a single inclined cylinder engine according to the present invention having a crank room formed by a crank case 1 integrally provided with a cylinder and covered at its rear opening with a side cover 2, in other words, when sectionally viewed in a side opposite to side cover 2, wherein a flywheel is disposed on a side of side cover 2;

Fig. 6 is a sectional rear view of the same, that is, when sectionally viewed in the same side with side cover 2;

Fig. 7 is a crass-sectional view of' the same, taken on line I - I of Fig. 5;

Fig. 8 is a cross-sectional view of the same, in its upper half area taken on line II-II of Fig. 6, and in its lower area taken on line II' - II' of Fig. 6;

Fig. 9 is a cross-sectional view of the same, taken on line III-III of Fig. 5,

Fig. 10 is a circuit diagram of a lubricating oil passage R from the interior of side cover 2 to various portions of the engine;

Fig. 11 is a fragmentary sectional view, on an enlarged scale, of the lubricating oil passage close to a cam shaft bearing portion 2g seen in Fig. 10;

Fig. 12 is a cross-sectional view taken on line IV-IV of Fig. 5, of a single inclined cylinder unit engine according to the present invention having a crank room formed by a crank case 1 integrally provided with a cylinder and covered at its rear opening with a side cover 2, in other words, when sectionally viewed in a side opposite to side cover 2, wherein a flywheel is disposed on a side of side cover 2 and a balancer shaft 4 projects outwardly from the side opposite to the side cover 2 so as to provide an output terminal;

Fig. 13 is a cross-sectional view, in its upper half area taken on line II - II of Fig. 6, and in its lower area taken on line II' - II' of Fig. 6, of a single inclined cylinder unit engine, wherein a flywheel housing is integrally formed by a side cover and a crank shaft projects outwardly in opposite to the flywheel so as to provide an output terminal;

Fig. 14 is a front view of an engine unit with a single inclined cylinder engine cooled by water (a water-cooled single inclined cylinder engine unit);

Fig. 15 is a right side view partly in section of the same;

Fig. 16 is a view taken on line V - V of Fig. 15;

Fig. 17 is a right side view of the water-cooled single inclined cylinder engine unit, partly showing a sectional right side view of a fan case 60, a radiator cover 61, and a right side stay 46, when a fuel tank 47 is removed therefrom;

Fig. 18 is a cross-sectional view taken on line VI - VI of Fig. 17, and

Fig. 19 is a cross-sectional view taken on line VI - VI of Fig. 17.

The Best Mode for Carrying Out of the Invention

[0058] The hereinafter various embodiments about a single inclined cylinder engine according to the present invention will be described in assumption that a crank shaft is oriented horizontally and longitudinally. An crank case 1 is open at its one side surface. The open side thereof is designated as a rear side in all of the embodiments. As shown in Figs. 3, 4 and others, the rear open end thereof is covered with a side cover 2. As the best shown in Fig. 1, crank case 1 integrally forms an upwardly and leftwardly projecting cylinder 1c at its upper left side. A cylinder head 26 is disposed on the

top of cylinder 1c and is covered at its top with a cylinder head cover 27. Onto the front surface of cylinder head 26 is attached a carburetor 31. A glow plug 32 is inserted into cylinder head 26, and a fuel injection valve 33 is inserted into the same through cylinder head cover 27. Fuel injection valve 33 is fed with fuel discharged from a fuel injection pump 17 attached onto crank case 1 through a fuel injection pipe, so as to inject the fuel into a combustion chamber (to be detailed, a sub combustion chamber) in cylinder head 26. In cylinder 1c is disposed a piston 25 so as to be slidable along an axis A of cylinder 1c (see Fig. 5). Cylinder portion 1c may be extended rightwardly slantwise from the upper right side of crank case 1. However, as the above mentioned, all the later discussed embodiments will be described in assumption that cylinder 1c is formed by the upper left portion thereof.

[0059] A crank room portion 1a of crank case 1 and a crank room portion 2a of side cover 2 are united by joining of crank case 1 and side cover 2 so as to constitute a crank room therein. The construction of various parts in the crank room will be explained. As the best shown in Fig. 7, a crank shaft 3 is disposed horizontally and longitudinally. A front end portion toward the flywheel and a rear end portion opposite to the flywheel, defining an axis of crank shaft 3, constitute a first crank journal 3a and a second crank journal 3b, respectively. Referring to an embodiment shown in Figs. 1 through 4, first crank journal 3a is journalled by side cover 2 and projects rearwardly outward, and second crank journal 3b journalled by the front wall of crank case 1. On the other hand, referring to another embodiment shown in Figs. 5 through 9, first crank journal 3a is journalled by the front wall of crank case 1 and projects forwardly outward, and second crank journal 3b journalled by side cover 2. In the both embodiments, a flywheel 40 is fixed around the outer projecting portion of first crank journal 3a. With respect to the latter embodiment as shown in Figs. 5 through 9, flywheel 140 is clamped onto the utmost end of first crank journal 3a by a bolt 40a. As the best shown in Fig. 7, a cooling fan 41 may be provided on flywheel 40, so as to send air to a radiator (not shown). Additionally, in the both embodiments, second crank journal 3b projects outwardly (that of the former embodiment of Figs. 1 through 4 is forward, and that of the latter embodiment of Figs. 5 through 9 rearward), which is available to be used for an output shaft or for mounting a cooling fan apart from the flywheel.

[0060] Figs. 7 and 9 show that first crank journal 3a is journalled by a crank shaft bearing portion 1d formed by the front wall of crank case 1, and second crank journal 3b by a crank shaft bearing portion 2f formed by side cover 2 according to the latter embodiment of Figs. 5 through 9. Similarly, first and second crank journals 3a and 3b of the former embodiment of Figs. 1 through 4, while being not shown, are journalled by crank shaft bearing portions 2f and 1d, respectively.

[0061] In crank room 1a of crank case 1, front and rear crank journals 3a and 3b form respective crank arms 3c and balance weights 3d at their internal ends. A crank pin 3e is formed between both crank arms 3c. A large end of a connecting rod 24 is rotatably provided on crank pin 3e and a small end thereof is connected to piston 25 in cylinder 1c.

[0062] As shown in Fig. 7, in crank room 1a, a balancer shaft 4 is disposed in parallel to crank shaft 3 (horizontally and longitudinally) , so as to be journalled at its front end by the front wall of crank case 1, and at its rear end by side cover 2. As the front view of Fig. 5, balancer shaft 4 is disposed downwardly leftward from the axis of crank shaft 3 (the axis of crank journals 3a and 3b), or in other words, below cylinder 1c. A balancer 4a projecting from the intermediate portion of balancer shaft 4, as shown in Fig. 7, possibly passes through the space between front and rear balance weights 3d, thereby enabling balancer shaft 4 to approach crank shaft 3 in some measure. Both shafts 3 and 4 are rotated in opposite directions and phases so as to attenuate the rotational vibration of each other. When crank pin 3e is the most close to balancer shaft 4, balancer 4a is located in opposite to crank pin 3e about balancer shaft 4 (simultaneously, balance weights 3d are opposed to balancer 4a about crank pins 3e). During their rotation, the large end of connecting rod 24 does not interfere with balancer shaft 4. As the above mentioned, balancer 4a is rotated in the opposite phase to balance weights 3d so as to attenuate the vibration generated by the rotation of crank shaft 3. Balancer 4a is disposed above the top surface of oil pan 1b formed by the bottom portion of crank case 1 so as to be prevented from sinking in the lubricating oil in oil pan 1b.

[0063] As the best shown in Fig. 7, in the vicinity of the boundary between crank room portions 1a and 2a, a crank gear 6 is fixed around the rear crank journal (first crank journal 3a of the former embodiment shown in Figs. 1 through 4, or second crank journal 3b of the latter embodiment shown in Figs. 5 through 9) of crank shaft 3, and a first balancer gear 7 is fixed around balancer shaft 4 so as to engage with crank gear 6 all the time. A second balancer gear 8, which is smaller than first balancer gear 7, is fixedly disposed around balancer shaft 4 in adjacent to the outer side of first balancer gear 7.

[0064] Additionally, in crank room 1a, a cam shaft 5 is disposed in parallel to crank shaft 3 and balancer shaft 4 (horizontally and longitudinally) for driving the fuel injection pump and the inlet and exhaust valves. As shown in Fig. 9, the front end of cam shaft 5 is journalled by the front wall of crank case 1, and the rear end thereof by a cam shaft bearing portion 2g of side cover 2. In the vicinity of the boundary between crank room s 1a and 2a, a cam gear 9 is fixed around cam shaft 5 and engages with second balancer gear 8 all the time, as shown in Fig. 5. Since second balancer gear 8 is diametrically small as the above, cam gear 9 and first balancer gear 7, as shown in Fig. 5, can be disposed so as

to overlap partly when viewed in front, thereby enabling the clearance between both shafts 4 and 5 to be reduced. As a result, the required speed reduction ratio between shafts 4 arid 5 can be ensured even if cam gear 9 is not particularly large. Furthermore, since the locus of rotating balancer 4a is smaller than those of rotating crank arms 3c and balance weights 3d, the clearance between cam shaft 5 and balancer shaft 4 does not have to be particularly large while ensuring the speed reduction ratio between shafts 4 and 5.

[0065] When viewed in front, cam shaft 5 is disposed upwardly leftward from balancer shaft 4, so that it is located just below a portion or cylinder 1c slightly upward from its open bottom end. Since the clearance between shafts 4 and 5 is not particular large, the tilt angle of cylinder 1c does not particularly have to be upwardly large, so that cylinder 1c can be disposed rather horizontally, thereby entirely lowering the engine.

[0066] Onto the left side surface of crank case 1 is substantially horizontally attached fuel injection pump 17, and attached a fuel feed pump 18 before fuel injection pump 17 at substantially the same height. In crank room 1a, the pump driving portion constituted by the internal end portion of fuel injection pump 17 abuts against pump driving cam 5a on cam shaft 5, so that fuel injection pump 17 is driven by the rotation of cam 5a. Additionally, a pair of inlet and exhaust valve driving cams 5b are fixedly provided on cam shaft 5, so as to abut against ends of push rods 30 connected to rocker arms 29 for inlet and exhaust valves 28.

[0067] As shown in Fig. 9, for attaching pumps 17 and 18 onto crank case 1, a hole 1e for passing a lever 18e of fuel feed pump 18 therethrough, a hole 1f for insertion of fuel injection pump 17, and female screws 1g for fixture of pumps 17 and 18 to crank case 1 are all bored in parallel in the left side wall of crank case 1, so that all the extensions of holes 1e and 1f and female screws 1g cross an axis B of cam shaft 5 perpendicularly. Such concentrated boring of parallel holes 1e and 1f and female screws 1g at almost the same height in the common side of crank case 1 can be easily performed, which results in reduction of cost. When both pumps 17 and 18 must be detached or attached at one step, the work can be done easily and swiftly because of their location on the common side surface of crank case 1 at substantially the same height and in substantially the same direction. Thus, the maintenance for a fuel injection pump and a fuel feed pump comes to be improved.

[0068] The thick wall portion of side cover 2 in rear of cam shaft bearing portion 2g is provided therein with below-discussed various lubricating oil passages R along the rear end surface of side cover 2. As shown in Fig. 9, a crank shaft lubricating oil passage R4 of passages R is formed from the left side surface of side cover 2 to crank shaft bearing portion 2f supporting the rear crank journal (first crank journal 3a of the embodiment shown in Figs. 1 through 4, or second crank journal 3b of the other embodiment shown in Figs. 5 through 9). The extension of crank shaft lubricating oil passage R4 cross axis B of cam shaft 5 perpendicularly behind cam shaft bearing portion 2g, in other words, it is in parallel to holes 1e and 1f and female screws 1g at substantially the same height.

[0069] Crank shaft lubricating oil passage R4 is outwardly open at the left side surface of side cover 2. A lubricating oil filter 16 is optionally inserted horizontally into the opening portion of oil passage R4 so as to communication with the downstream side thereof, thereby feeding bearing portions 2f and 1d journalling crank journals 3a and 3b with filtrated lubricating oil. As a result, lubricating oil filter 16 is juxtaposed with pumps 17 and 18 on the same side surface of the engine, in the same direction and at substantially the same height. Thus, when the three members 16, 17 and 18 must be detached and attached in a process, the work can be performed easily and swiftly, thereby improving the maintenance of them.

[0070] As shown in Fig. 8, a primary lubricating oil filter 35 is disposed in side cover 2. The lubricating oil in the oil pan (oil pans 1b and 2b formed by the bottom portions of crank case 1 and side cover 2), which is filtrated by filter 38 is absorbed into a lubricating oil pump 12 through lubricating oil passages R in side cover 2, further filtrated through lubricating oil filter 16 and fed into various areas of the engine. The construction of lubricating oil passages R will be detailed later.

[0071] As shown in Fig. 5, a lubricating oil pump drive shaft 10 is disposed below cam shaft 5 and on the left side of balancer shaft 4 in parallel (horizontally and longitudinally). As shown in Fig. 8, driving shaft 10 is journalled by the interior portion of side cover 2 and extended into crank case 1. In crank case 1, a lubricating oil pump gear 11 is fixedly provided around driving shaft 10 and engages with first balancer gear 7 all the time. In side cover 2, lubricating oil pump 12 is formed around driving shaft 10. While the engine is driven, lubricating oh, pump 12 is driven by the rotation of shaft 10 following balancer shaft 4 through gears 7 and 11, so that the engine is entirely fed with lubricating oil from the interior of crank case 1.

[0072] A governor G is so constructed as follows: As shown in Fig. 8, the extensional portion of lubricating oil pump drive shaft 10 in crank case 1 is provided therearound with a centrifugal governor weight 13. Driving shaft 10 is slidably inserted through an axial cylinder 13a of governor weight 13. Axial cylinder 13a is further extended in proportion to the rotary force of driving shaft 10. A governor arm 14 pressed against the utmost end of axial cylinder 13a is rotated by the extensive action of axial cylinder 13a so as to integrally rotate governor lever 15 in a longitudinal direction. In this regard, lubricating oil pump gear 11 on lubricating oil pump drive shaft 10 is also used as a governor driving gear.

[0073] As shown in Fig. 8, in crank case 1 is longitudinally rotatably supported a fuel injection adjusting

arm 17a of fuel injection pump 17, with which the upper end of governor lever 15 is pivotally connected, so that the quantity of fuel discharged from fuel injection pump 17 is determined by the position of fuel injection adjusting arm 17a rotated together with governor lever 15.

[0074] A governor lever rotational fulcrum shaft 15a is laterally extended from a basis portion (a bottom) of governor lever 15 and supported by a left wall of crank case 1. Since arm 17a is disposed above shaft 10, shaft 15a, while being disposed below shaft 10 having gear 11 for driving governor G and fuel injection pump 17, does not have to be particularly lowered for ensuring the length of governor lever 15. Even if shaft 15a is disposed above oil pan 1b, the clearance between arm 17a and shaft 15a can be sufficiently ensured so as to provide an enough length of governor lever 15. Such lengthened governor lever 15 enables fine control of fuel injection.

[0075] Onto front surface of crank case 1 is attached a cooling water pump 22 so as to rotatably insert its driving shaft 20 into crank case 1 through the front surface thereof. As shown in Figs. 6 and 8, cooling water pump driving gear 21 is fixedly provided on the internal portion of cooling water pump drive shaft 20, and as shown in Figs. 6 and 7, a third balancer gear 19 is fixedly provided on balancer shaft 4 near the front wall of crank case 1. Gears 19 and 20 always engage with each other.

[0076] On balancer shaft 4, third balancer gear 19 is opposed to juxtaposed first and second balancer gears 7 and 8. First balancer gear 7 engages with crank gear 6 and lubricating oil pump driving gear (governor driving gear) 11, and second balancer gear 8 engages with cam gear 9, whereby fuel injection pump 17, lubricating oil pump 12 and governor G are concentrated. If third balancer gear 19 were disposed close to gears 7 and 8, a gear for driving the cooling water pump would be disposed along a surface including any of gears 7, 8 and 9, thereby compelling crank case 1 to be expanded at its portion surrounding the gears.

[0077] Due to the arrangement of third balancer gear 19 on balancer shaft 4 in opposite to gears 7 and 8, water cooling pump 22 comes to be disposed oppositely to fuel injection pump 17 and so forth, so as to drivingly connected with third balancer gear 19. Cooling water pump drive shaft 20 may be disposed substantially co-axially with lubricating oil pump drive shaft 10, so that the longitudinal and lateral space for disposal of lubricating oil pump 12 and cooling water pump 22 can be saved, thereby compacting crank case 1. Governor lever 15 comes to be disposed between centrifugal governor weight 13 (on shaft 10) and cooling water pump 22 (on shaft 20) in crank case 1. Thus, the engine can be compacted due to such utilization of the dead space between both driving shafts 10 and 20.

[0078] Lubricating oil pump 12 and cooling water pump 22 as the best shown in Fig. 8 can be exchanged with each other. In other words, lubricating oil pump 12 may be disposed in the front wall of crank case 1, and cooling water pump 22 in side cover 2. In this case, a driving shaft for cooling water pump 22 is combined with a governor driving shaft. Corresponding to lubricating oil pump 12 provided on the front surface of crank case 1 , primary lubricating oil filter 35 and lubricating oil filter 16 should be provided onto or into crank case 1 instead of side cover 2, and lubricating oil holes to be connected with inlet and outlet ports of lubricating oil filter 12 should be bored within crank case 1 instead of side cover 2.

[0079] As shown in the sectional front view of Fig. 5, balancer shaft 4, cam shaft 5 and lubricating oil pump drive shaft 10 are disposed in a direction along a line D1 radially (perpendicularly) extended from axis A with respect to the lower end of cylinder 1c, and both driving shafts 10 and 20 overlap along the same axis. Accordingly, fuel injection pump 17 driven by cam shaft 5, lubricating oil pump 12 and governor G driven by shaft 10, and cooling water pump 22 driven by shaft 20 are disposed adjacently to the group of shafts 4, 5, 10 and 20. As a result, there comes to be a dead space in a direction along a line D2 radially (perpendicularly) extended from axis A in opposite to line D1, or just above the top end of crank case 1. A starter motor 23 can be disposed in the dead space as the best shown in Fig. 5.

[0080] An output gear 23a of starter motor 23 engages with a gear 40a peripherally fixed on flywheel 40, so that flywheel 40 is rotated by the driving of starter motor 23 for starting of rotary of crank shaft 3. Starter motor 23 and a stater solenoid 23b are exchanged before and behind with each other between the embodiment of Figs. 1 through 4 and that of Figs. 5 through 9 (similar with the below-discussed embodiment of Figs. 14 through 19), in correspondence to gear 40a. In this regard, according to the embodiment of Figs. 1 through 4, a starter bracket 2h as shown in Figs. 2 and 3 is integrally extended upwardly in a plate-shape from side cover 2, thereby supporting starter motor 23 and starter solenoid 23b substantially horizontally. According to the embodiment of Figs. 5 through 9, a starter bracket 39, which is separate from crank case 1, is erected upwardly from the upper portion of the front surface of crank case 1 for the same purpose.

[0081] Explanation will next be given on the construction of the inlet port to lubricating oil passages R formed within the wall of side cover 2 in accordance with Figs. 5, 7, 10 and others. As the abovementioned, in the bottom of the crank room consisting of crank room portions 1a and 2a, the oil pan consisting of oil pan portions 1b and 2b is formed by the bottom portions of crank case 1 and side cover 2. In a side wall of side cover 2 constituting oil part 2b are bored left and right adjacent lubricating oil inlet ports 2c and 2d as shown in Fig. 5. When sectionally viewed in side, lubricating oil inlet port 2c is approximately disposed at the lateral center of oil pan 1b or 2b. Lubricating oil inlet port 2d is laterally opposed to the group of shafts 4, 10 and so forth. Inlet

port 2c is open at a slightly lower portion than inlet port 2d. An inlet pipe 34 is extended horizontally into the oil pan from either inlet port 2c or 2d as shown in Fig. 7. Especially when the engine is set in a tilted formation so as to make the front surface of crank case 1 (the opposite surface to side cover 2) close to the earth, the surface of lubricating oil which stay in the bottom of the crank room of 1a and 2a is marked out by a chain line L5. Inlet ports 2c and 2d become higher than oil surface L5, however, inlet pipe 34 is long enough to sink their open ends below oil surface L5, so that lubricating oil at the bottom of the oil chamber can be supplied into either of inlet ports 2c and 2d through inlet pipe 34 extended therefrom.

[0082] The lubricating oil inlet ports may be open at the inner surface of crank case 1 consisting crank room 1a (or oil part 1b) in opposite to side cover 2. When the installed engine is sloped so as to direct side cover 2 rather downward, the surface of lubricating oil collected in the bottom of the crank room is marked out by a chain line L6. However, the lubricating oil can be supplied into at least one inlet port opening at oil part 1b through an inlet pipe like 34 extended therefrom.

[0083] In the state that the engine is installed so as to lay the bottom thereof horizontally, the surface of lubricating oil collected in the oil pan of 1b and 2b is marked out by a chain line L1 when approaching its maximum, and by a chain line L2 when approaching its minimum. The collected lubricating oil surface is basically horizontal, however, it is tilted when the vibration is generated by the rotation of shafts. Lubricating oil inlet port 2c is advantageous in its position at about the lateral center of oil pan 2b against lateral inclination of the lubrication oil surface, and in the lowest position at oil pan 2b (lower than inlet port 2d) against longitudinal inclination thereof. Therefore, when the engine is set with its bottom laid horizontally, inlet port 2c should be preferred.

[0084] In the case that the engine is installed so as to erect cylinder 1c approximately vertically, the surface of lubricating oil collected in the oil pan of 1b and 2b is relatively inclined to the bottom of engine as marked out by a chain line L3 when approaching its maximum, and by a chain line L4 when approaching its minimum. Lubricating oil inlet port 2d comes to be relatively disposed at about the lateral center of the collected lubricating oil. Also, it becomes lower than inlet port 2c, furthermore, the lowest in the collected lubricating oil. Thus, inlet port 2d should be preferred.

[0085] In this regard, in the crank room of 1a and 2a, while balancer shaft 4 and lubricating oil pump drive shaft (governor driving shaft) 10 are in the left side area below the axis of crank shaft 3, there is a dead space in the right side area. Especially to prevent gears or the like provided on shaft 10 from sinking the collected lubricating oil, the engine is preferably disposed so as to make cylinder 1c close to vertical, thereby collecting the lubricating oil in the right area below crank shaft 3 with the surface thereof as marked by line L3 or L4. However, in case that cylinder 1c is to be disposed substantially horizontally, the lubricating oil comes to be collected in the left area below crank shaft 3, therefore, left inlet port 2c is preferred. In this case, it can be understood that, for avoiding the interference of the collected lubricating oil with the gear and the like on shaft 10, the engine is preferably sloped so as to direct either the side cover 2 or the front surface of crank case 1 rather downward, thereby disposing the lubricating oil surface as marked by line L5 or L6.

[0086] Explanation will next be given on lubricating oil passages R consisting of R1 through R6 formed within side cover 2 in accordance with Figs. 8. 9, 10, 11, and so forth. In this regard, they will be described on the assumption that the bottom of engine is laid horizontally (the collected lubricating oil in the oil chamber of 1a and 2a is marked out by line L1 or L2).

[0087] Lubricating oil inlet ports 2c and 2d are connected with horizontal lubricating oil introducing passage 2e formed in side cover 2 along the rear end surface of side cover 2. Passage 2e is removably provided at its outside opening with primary lubricating oil filter 35 and plugged by a cap 35a which is integral with oil filter 35. The opening of passage 2e is also used for draining, so that the lubricating oil collected in the crank room of 1a and 2a can be drained through inlet port 2c or 2d and passage 2e.

[0088] In side cover 2 is bored a pump suction passage R1 substantially upward from primary lubricating oil filter 35, so as to be connected with a section port 12a of lubricating oil pump 12, which is disposed longitudinally in side cover 2 as the above-mentioned, and is bored a main lubricating oil passage R2 substantially vertically from a discharge port 12b of pump 12.

[0089] For the particular purpose of lubrication of crank shaft 3 with fine filtrated oil, lubricating oil filter 16 is laterally disposed on the left side surface of side cover 2 above lubricating oil pump 12, and filter suction oil passage R3 is branched from passage R2 to an entrance of filter 12. A crank shaft lubricating oil passage R4 is substantially laterally bored from an exit 16a of filter 16. In the left side of crank case 1 are bored holes 1e and 1f, which are substantially as high as oil passage R4 in substantially parallel thereto, for providing fuel feed pump 18 and fuel feed pump 17 therethrough, whereby oil passage R4 can be easily bored almost simultaneously with boring of holes 1e and 1f.

[0090] As shown in Fig. 10, a relief valve 36 is interposed between discharge port 12b of lubricating oil pump 12 and the start point of filter suction oil passage R2 in main lubricating oil passage R2.

[0091] In crank shaft 3 are drilled lubricating oil holes 3c, 3d, 3e and the like, crank shaft lubricating oil passage R4 is connected with lubricating oil hole 3c through crank shaft bearing portion 2f which supports rear crank journal 3a or 3b in side cover 2. Lubricating oil flows through holes 3c, 3d, 3e and the like in crank

shaft 3, so as to be fed into various lubricating oil passages bored in the wall of crank case 1 through crank shaft bearing portion 1d which supports front crank journal 3b or 3a in the front side of crank case 1.

[0092] Additionally, an oil pressure switch 37 is disposed at an intermediate portion of passage R4 for electrically operating the adjustment of lubricating oil pressure to crank shaft 3.

[0093] cam shaft lubricating oil passage R5 is branched from main lubricating oil passage R2 in opposite to filter suction oil passage R3 co-axially therewith. The final end of passage R5 is disposed adjacently to cam shaft bearing portion 2g of side cover 2. Passage R5 communicates with the interior space of crank room 2a through a diametrically small escape hole R6. The internal end of cam shaft bearing portion 2g is just adjacent to the rear surface of cam gear 5a on cam shaft 5, and is partly cut away at its portion facing cam gear 5a, so as to space a gap C from the rear surface of cam gear 5a. The opening of escape hole R6 to crank room 2a is located just above gap C, so as to stick the dropped oil from escape hole R6 onto cam shaft 5. Thus, lubricating oil is applied on the surface of cam shaft 5 and permeates the gap between cam shaft bearing portion 2g and the end of cam shaft 5, so as to lubricate the radially stressed portion thereof, thereby smoothing the rotation of cam shaft 5 and improving the durability thereof.

[0094] In this regard, due to the drop of lubricating oil from escape hole R6, the increase of oil pressure in cam shaft lubricating oil passage R5 can be restricted, thereby regulating the oil pressure in main lubricating oil passage R2 in cooperation with relief valve 36.

[0095] Additionally, main lubricating oil passage R2 is further extended substantially upwardly through the joint portion between filter suction oil passage R3 and cam shaft lubricating oil passage R5. In cylinder 1c is extended a lubricating oil hole R7 from about the top end of passage R2 to a bolt hole for insertion of a head bolt 38 which clamps cylinder head 26 with cylinder 1c. Furthermore, in cylinder head 26 are bored a rocker arm lubricating oil passage R8, which is extended from the bolt hole for head bolt 38 to rocker arms 29, and the like.

[0096] Next, explanation will be given on an embodiment wherein a balancer shaft of a single inclined cylinder unit type engine is utilized as an engine output shaft. The sectional front and rear views of the engine according to the present embodiment are those of the engine according to the above embodiment as shown in Figs. 5 through 9. Therefore, Figs. 5 and 6 are employed as the sectional front and rear views of the engine according to the present embodiment. Fig. 12 is designated as a view taken on line IV-IV of Fig. 5. In this regard, the shapes of some component parts such as crank shaft 3, flywheel 40 and side cover 2, the support structure of crank shaft 3, and so forth, are different from those in the above embodiment, however, the present embodiment will be described on the assumption that they are identical or similar.

[0097] In similar with those as shown in Figs. 5 through 9, flywheel 40 is disposed on the front surface of crank case 1, and first crank journal 3a toward flywheel 40 is designated as the front end of crank shaft 3. Flywheel 40 itself may be used as an engine output member, so that an input terminal of a load may be connected to flywheel 40 or first crank journal 3a disposed at a center of flywheel 40.

[0098] Referring to Fig. 12, second crank journal 3b is journalled in side cover and is blocked therein. It may be extended outwardly (backwardly) from side cover so as to constitute an engine output shaft, as the best shown in Figs. 3 and 7. However, the engine output shaft of second crank journal 3b must be used on the assumption that the input terminal of the load to be connected therewith is rotated in a relatively opposite direction to that to be connected with flywheel 40. Accordingly, if the input rotational direction of the load receiving power from first crank journal 3a (flywheel 40) is relatively identical with that from second crank journal 3b, there comes to be required such a complicated labour that, while the input terminal of one load is directly connected with flywheel 40, that of the other load is drivingly connected with the output shaft of crank journal 3b through a reversing transmission like belts and pulleys, gears, or chains and sprockets.

[0099] According to the present embodiment, the end portion of balancer shaft 4 journalled by side cover 2 is further extended outwardly so as to constitute a power-take-out terminal 4b. Balancer shaft 4 is rotated in an opposite direction to and at the same rotary speed with crank shaft 3. In this regard, the teeth of crank gear 6 is as many as those of first balancer gear 7 engaging therewith. When power-take-out terminal 4b and crank journal 3a close to flywheel 40 are viewed in one way, they seen to rotate in opposite directions at the same speed. However, when each of them is viewed in an opposite direction to the other, they seem to share the same direction and speed of their rotation. Therefore, if only a load is correspondent to either power-take-out terminal 4b or crank journal 3a in its input rotational direction, whichever of front and rear sides of the engine is to be drivingly connected with the load in correspondence to some requirements like that about a position for mounting the engine, the load can be directly connected thereto without any additional or modified transmission for its input or output rotational direction or speed. Also, a pair of such above loads, whose input terminals are oneway-rotatable relatively in the same direction and at the same speed, can be directly connected to both the front and rear sides of the engine, respectively. As a result, there conies to be saved the cost for transmission between the engine and a load, or manufacture of loads.

[0100] If the engine of the present embodiment is to be constructed so as to output its power from only the

side where flywheel 40 is disposed, the rear end of balancer shaft 4 may be blocked in side cover 2 (without outwardly projecting power-take-out terminal 4b). Also, if the engine power is to be taken out from only terminal 4b, a connection portion to a load may be removed away from flywheel 40 or first crank journal 3a. Each of the both styles requires modification of only balancer shaft 4 and side cover 2, or only flywheel 40 and crank shaft 3, without that of other parts, thereby saving the increase of exclusive parts and the cost in modification for the styles. Thus, the single inclined cylinder engine can be comprehensively modified at low cost with respect to its output position.

[0101] Referring to Fig. 13, there is an embodiment showing that an engine provided on the side of its side cover with a flywheel, wherein a flywheel housing is integrally formed by the side cover. The engine of the present embodiment looks the same in sectional front and rear views with that of the further above embodiment as shown in Figs. 5 through 9. Therefore, Figs. 5 and 6 will be employed as the sectional front and rear views of the engine according to the present embodiment. Fig. 13 is cross-sectional view, taken on line II - II in a part, and taken on line II' - II' in the other part. The members, which are substantially identical with those of the aforesaid embodiments in spite of difference in shape or the like, are marked by the same reference numerals.

[0102] Regarding to the present embodiment, a side cover 2' replacing side cover 2, which integrally forms a flywheel housing 2'c, is provided for covering the rear opening of crank case 1. Side cover 2' forms a flywheel housing 2'c at the outside of a crank room 2'a, which is the couterpart of crank room 2a of side cover 2, and a crank shaft bearing portion 2'b, which supports first crank journal 3a. A flywheel 31 is fixed onto the outer (rear) end of first crank journal 3a projecting rearwardly in flywheel housing 2'c. The outer end of flywheel housing 2'c is cut away so as to provide a joint surface 2'd for connection of a load. When a load is joined on joint surface 2'd, it naturally comes to be drivingly connected with flywheel 40 so as to follow crank shaft 3 in rotation. Additionally, in the present embodiment, second crank journal 3b projects outwardly (forwardly) from the front surface of crank case 1 so as to be used as a power-take-out terminal.

[0103] Thus, the present engine can save the number and cost of parts like a bolt or pin, which are required to locate or fix a separate flywheel housing to the aforesaid engine.

[0104] Also, the present engine can be light because the increase of weight caused by attachment of the separate flywheel housing is out of consideration.

[0105] Furthermore, in comparison with crank case 1, a side cover like 2 or 2' can be simply, easily and compactly modified so as to provide, remove, or deform an integral flywheel housing at low cost by means of diecasting.

[0106] Finally, explanation will be given on an embodiment of a water cooled single inclined cylinder unit type engine as shown in Figs. 14 through 19. In the present embodiment, the main engine body thereof will be named as an "engine" and described in accordance with Figs. 1 through 9. The engine, which is provided therearound with attachments such as a fuel tank, a cooling fan, a fan case, a radiator, a radiator cover, a muffler, an air cleaner, and so forth, and provided with standing means for its placing, will be named as an "engine unit". The engine regarding to the present embodiment can be placed whether its crank shaft is oriented horizontally or vertically. However, in the present embodiment, it is assumed that the crank shaft is disposed horizontally. To additional assumption, flywheel 40 is disposed on the front surface of crank case 1 (in other words, the engine as shown in Figs. 5 through 9 is applied), and cooling fan 41 is provided on flywheel 40 as the above-mentioned embodiment so as to be rotated together with flywheel 40.

[0107] The structure of attachments like a fuel tank and a radiator for construction of the engine unit will be described in accordance with Figs. 14 through 19. At first, referring to placing of the engine, crank case 1 forms on each of its left and right side surfaces four bosses 1h bored by bolt holes. A foot plate 43 is placed on four bosses 1h on each lateral side surface of crank case 1 and clamped by four bolts 44. A horizontal base plate 42 is interposed between the bottom end of crank case 1 and the bottom end of each foot plate 43 and fixed thereto. The engine is fixedly mounted to a surface of a correspondent place through lest and right base plates 43 by bolts.

[0108] A draining bolt 45 is substantially horizontally screwed into crank case 1 adjacent to its bottom portion from its right side surface. When draining bolt 45 is removed, the lubricating oil is drained from the crank room in crank case 1 and side cover 2. Right foot plate 43 is bored by a hole 43a, which allows draining bolt 45 and a wrench to pass therethrough.

[0109] On the right side (opposite to the cylinder 1c when viewed in front or along crank shaft 3) of the mounted engine is disposed a fuel tank 47. In this regard, a pair of bosses 1i having vertical bolt holes therein project upwardly from the top of the right side surface of crank case 1. A pair of fixing bottom portions 46a of a right stay 46 is fixedly put on both bosses 1i through bolts 49, thereby erecting right stay 46. The upper end of erected right stay 46, when viewed in front, is bent rightwardly at about a 90 degree so as to provide an engaging portion 46b. Engaging portion 46b corresponds to the top of fuel tank 47 in shape, so as to be engaged over the top. The inside surface of engaging portion 46b is spaced from the top surface of fuel tank 47, so that the engagement between the both is something free. An elastic vibration-isolating pad 50 like rubber or sponge, as shown in Fig. 5, is interposed between engaging portion 46b and fuel tank 47, so that

the vibration of fuel tank 47 is permitted within engaging portion 46b (the fact is that the vibration of engaging portion 47 is permitted against the top of fuel tank 47).

[0110] A pair of vibration-isolators 51 made of elastic material are disposed just under two lower bolts 44 on right foot plate 43. On the other hand, fuel tank 47 is provided at its surface facing the right side of crank case 1 with a fixture plate 47a, which is attached onto right foot plate 43 through vibration-isolators 51. Fuel tank 47 is provided at the inside surface of fuel tank 47 with a pair of recessed portions 47c so as to prevent fuel tank 47 from interference with the heads of two upper bolts 44 on right foot plate 43. Fixture plate 47a is bored by holes 47b so as to permit the other heads of two lower bolts 44 to freely pass therethrough, thereby avoiding their interference with fuel tank 47.

[0111] Thus, vertically elongated fuel tank 47, while having a simple construction, is vibration-isolating supported at its upper portion by right stays 46 and at its lower portion by right foot plate 43, In this regard, right stays 46 and right foot plate 43 do not require particular strength for support fuel tank 47 steadily. The vibration generated from the engine (crank case 1) is not directly propagated to fuel tank 47, so that the waving of fuel in fuel tank 47 can be restricted. As discussed below, right stays 46 are also used for supporting a radiator 52 (a radiator holder 54) and a radiator cover 61, thereby being advantageous in the number reduction of parts.

[0112] The inside surface of fuel tank 47 is shaped in correspondence with the right side surface of crank case 1, so that fuel tank 47 containing fuel is directly fit onto crank case 1, thereby effectively cooling crank case 1.

[0113] Fuel tank 47 is increased in its volume due to its inside surface fit to the upper and lower recessed portions which appears on the right side of crank case 1.

[0114] Fuel is deeply filled in such vertically elongated fuel tank 47. Even if the engine is slantingly disposed so as to make the surface of fuel in fuel tank 47 relatively inclined, the fuel surface does not become lower than an oil supplying port of fuel tank 47 toward fuel feed pump 18 unless the fuel has been consumed sufficiently, thereby avoiding the waste of refueling.

[0115] There can be obtained a noise-proof effect in that fuel tank 47 covers over the entire right side surfaces of crank case 1 and side cover 2. Additionally, balancer shaft 4 and cam shaft 5 are disposed below cylinder 1c which is disposed on the left side of the engine (opposite to fuel tank 47), so that they do not exist in the right side space of crank shaft 3. As a result, the right side portion of crank case 1 becomes so compact as to enlarge fuel tank 47 covering thereover.

[0116] Fan case 60 is vertically disposed over flywheel 40 and cooling fan 41 (on the front surface of crank case 1 of the present embodiment). Fan case 60 has a front plate portion 60a disposed in front of flywheel 40 and cooling fan 41. An air take-in window 60b is open at front plate portion 60a where facing the area surrounded by cooling fan 41. A side plate portion 60c is provided along flywheel 40 between its left side portion (the side toward cylinder 1c) and its bottom end. Side plate portion 60c is cut away at the right side of fan case 60 toward fuel tank 47. The cutaway opening is correspondent to left side surface 47c of fuel tank 47. The right side edge of front plate portion 60a and the front surface of fuel tank 47 overlap each other in the vicinity of left side surface 47c.

[0117] Thus, in front of crank case 1 is provided a volute guide surrounding cooling fan 41 for guiding the centrifugal wind blown by cooling fan 41, which is enclosed at the right side thereof by fuel tank 47, and between the bottom end and the left side thereof by fan case 60. The cooling wind is guided clockwise in a front view, and introduced upwardly into radiator 52 through the left side area of cooling fan 41.

[0118] If a conventional structure for supplying radiator 52 with air were employed, a volute guide which is separate from fan case 60 would be disposed along the right side surface of fan case 60, or a right side surface of fan case 60 is integrally formed by itself, so that there would have to be a gap between such right side volute guide and the left side surface of fuel tank 47. Accordingly, fuel tank 47 would have to be offset rightwardly outward for ensuring the volume thereof, thereby enlarging the engine. Otherwise, if the right side portion of fuel tank 47 were to be compacted, the volume of fuel tank 47 would have to be reduced as large as the above-mentioned gap. However, since fuel case 47 according to the present embodiment is open at its right side surface so as to use left side surface 47c of fuel tank 47 as a part of a volute guide, there is not the above-mentioned gap, thereby ensuring both compactness and large capacity of fuel tank 47.

[0119] While passing through the volute guide constituted by fan case 60 and fuel tank 47, the cooling wind cools the lower portion of the front surface of crank case 1 directly, and it also cools left side surface 47c of fuel tank 47, thereby cooling the right side surface of crank case 1 which is adjacent to left side surface 47c. Thus, crank case 1 is substantially entirely cooled during the cooling wind passing through the volute guide.

[0120] Fan case 60 forms a tab 60d at the upper end of front plate 60a thereof. A middle stay 55 projecting from starter bracket 39 is fixed to tab 60d by a bolt or the like. On the left side portion of fan case 60 are provided an upper tab 60e, a middle tab 60f and a lower tab 60g. Tab 60e is clamped onto a left stay 56 projecting from cylinder head 26, tab 60f onto a seat 1j formed by a front surface of cylinder 1c, and tab 60g onto a seat 1k formed by a front surface of crank case 1, respectively, by bolts. Fuel tank 47 is provided on the front end of left side surface 47c with leftwardly projecting upper tab 47d and lower tab 47e, which are fixed to overlapping front plate portion 60a of fan case 60 by bolts or the like. Fan case 60 and left side surface 47c of fuel tank 47 are

fixedly disposed by such means.

[0121] In this regard, it is apparently inconsistent with fuel tank 47 being vibration-isolating supported in relative to right foot plate 43 that tabs 47d and 47e of fuel tank 47 are fixed to front plate portion 60a of fan case 60 fixed onto the front surface of crank case 1 (through tabs 60f and 60g). However, vibration-isolators 51 between fuel tank 47 and right foot plate 43 are provided for absorbing the radial vibration generated from rotating crank shaft 3. During the driving of the engine, crank shaft 3 hardly generates a thrust vibration in its axial direction. Thus, fuel tank 47 fixed to crank case 1 through fan case 60 is scarcely vibrated in a large scale.

[0122] Radiator 52 is held by radiator holder 54 so as to be substantially horizontally disposed above starter motor 23 and starter solenoid 23b, however, rather upwardly slanted for avoiding the interference with starter motor 23 and starter solenoid 23b.

[0123] A front middle tab 54a, a left tab 54b and a right tab 54c project from the bottom edge of radiator holder 54 and are vibration-isolating supported by middle stay 55, left stay 56 and right stay 46, respectively, through vibration isolators 58.

[0124] Below such supported radiator 52, a space S is ensured between the top end of crank case 1 (and side cover 2) and the upper portion of inclined cylinder 1c. Starter motor 23 and stater solenoid 23b (hereinafter they will be named as "stater motor 23 and the like") can be entirely disposed in space S. Even if stater motor 23 and the like are disposed there, a sufficient large space is ensured above starter motor 23 and the like because space S is upwardly enlarged, thereby permitting radiator 52 facing the space to have a sufficient large capacity. As a result, the engine can be effectively cooled.

[0125] Radiator 52 is covered at the upper and four sides thereof with radiator cover 61, thereby being sound-proof. Radiator cover 61, containing space S, provides a cooling-wind duct. As a result, the cooling wind through space S is enclosed by radiator cover 61 without escape, so that the whole of the air introduced into fan case 60 through air take-in window 60b can be guided into radiator 52, thereby increasing the amount of heat exchanged by radiator 52 so as to improve the cooling efficiency of the engine. A substantially vertical front surface of radiator cover 61 is overlapped at its bottom edge with the top ends of front plate portion 60a of fan case 60 and that of the front surface of fuel tank 47. A rear surface of radiator cover 61 is extended downwardly to the vicinity of the top end of side cover 2. A rear stay 57 projecting from side cover 2 is clamped onto the rear surface of radiator cover 61. The left side surface of radiator cover 61 covers the top end of left side surface portion 60c of fan case 60 and the upper portion of cylinder 1c. The right side surface of radiator cover 61 is overlapped at its bottom edge thereof with the top end of right side surface of fuel tank 47.

[0126] The top of the front right corner of radiator cover 61 falls a degree, so as to provide a refueling step portion 61b, which allows a refueling opening upwardly projecting from fuel tank 47 to pass therethrough. A refueling cap 48 is provided onto the refueling opening upwardly projecting from portion 61b. A radiator cap 53 also projects from the top of radiator cover 61. As a result, the refueling opening of fuel tank 47 and the radiator-liquid-supply opening of radiator 52 are disposed above radiator cover 61, thereby easing the respective supplying works. The refueling opening of fuel tank 47 is so long as to restrict the amount of fuel leak from the gap between the refueling opening and refueling cap 48 when the engine is slantingly mounted. The top level of fuel tank 47 disposed on the right side of crank case 1 can be higher so long as the refueling opening is extended upwardly, thereby increasing the capacity thereof.

[0127] Onto the inside of the top surface of radiator cover 61 are clamped tabs 54d, 54e and so forth projecting from the left and right ends of radiator holder 54 by bolts. As the above mentioned, the right side surface of radiator cover 61 is fixed to right stay 46. Radiator cover 61 is provided at the portion of the top surface of radiator cover 61 facing the top surface of radiator 52 with an air exhaust opening 61a. A seal 59 looking like a vertical plate is interposed between the top end portion of radiator holder 54 and the inside edge of air exhaust opening 61a.

[0128] Radiator 52, which is integral with radiator holder 54, is supported by the upper portion of crank case 1 in the condition that tabs 54a, 54b and 54c are vibration-isolating supported thereon through vibration isolators 58. Accordingly, the vibration of the engine is not directly propagated to radiator 52. Radiator cover 61 is directly connected with radiator 52 through tabs 54d and 54e, whereby the vibratory isolating effect of radiator 52 extends to radiator cover 61. As a result, the vibratory noise of the engine is little diffused outwardly from radiator cover 61.

[0129] The cooling wind from the top opening of fan case 60 is introduced into the bottom of' radiator 52 through the upper area of space S above starter motor 23 and the like so as to be exchanged. Seal 59 prevents the air exhausted from the upper portion of radiator 52 from escape to other areas in radiator cover 61. Accordingly, the exhausted air is prevented from mixing with the cooling wind before entering radiator 52, thereby being certainly exhausted from upper air exhaust opening 61a.

[0130] Conventionally, a fuel tank has been disposed above a radiator cover, whereby the engine could not been compacted vertically. Additionally, the fuel tank was subject to the air exhausted upwardly from the radiator, thereby heating fuel in the fuel tank. However, in the present embodiment, vertically elongated fuel tank 47 is disposed on the right side of crank case 1 and side cover 2, whereby, while fuel tank 47 has a sufficient capacity, there is not required a space for fuel tank 47

above radiator 47. In the space above crank case 1 are disposed only radiator 52 and radiator cover 61 except starter motor 23 and the like. Thus, the engine unit becomes vertically compact and fuel tank 47 is safe from the air exhausted from radiator 52.

[0131] Above cylinder head 26 and cylinder head cover 27 disposed lower than radiator cover 61 at the right side of radiator cover 61 is ensured a space for disposal of a muffler 62. Below muffler 62, in front of cylinder head 26, cylinder head cover 27 and fuel feed pump 18 and fuel injection pump 17 disposed onto the left side of crank case 1, and at the left side of left side surface 60c of fan case 60 is ensured another space for disposal of an air cleaner 63. Air cleaner 63 is connected to the front end of carburetor 31 disposed onto the front surface of cylinder head 26 through an air conduit.

[0132] Such disposed muffler 62 and air cleaner 63 are neither offset leftwardly from cylinder head 26 nor upwardly from the top of radiator cover 61, thereby improving the compactness of the engine unit.

Possibility of Industrial Use

[0133] As the aforesaid, the single inclined cylinder engine according to the present invention can be used as a compact engine for driving a load such as a dynamo, a pump and a compressor, or for driving a small vehicle.

Claims

1. A single inclined cylinder engine comprising:

   a crank case;
   a horizontal crank shaft disposed in said crank case;
   a inclined cylinder provided on said crank case, and
   rotary shafts disposed in said crank case in parallel to said crank shaft , said rotary shafts including at least a balancer shaft and a cam shaft, wherein axes of said balancer shaft and said cam shaft are disposed below an axis of said cylinder.

2. A single inclined cylinder engine as set forth in claim 1, further comprising:

   a crank gear fixedly provided on said crank shaft ;
   a first balancer gear fixedly provided on said balancer shaft;
   a diametrically small second balancer gear fixedly provided on said balancer shaft to be adjacent to said first balancer gear, and
   a cam gear fixedly provided on said cam shaft, wherein said crank gear, said first balancer gear, said second balancer gear and said cam gear are disposed in the vicinity of one side ends of a group of said rotary shafts, said crank gear engages with said first balancer gear, and said second balancer gear engages with said cam gear.

3. A single inclined cylinder engine as set forth in claim 2, further comprising:

   a lubricating oil pump having a pump drive shaft in parallel to said group of rotary shafts, wherein said lubricating oil pump is disposed in the vicinity of said one side ends of said group of rotary shafts, and said lubricating oil pump drive shaft engages with said cam gear;
   a third balancer gear fixedly provided on said balancer shaft in the vicinity of the other side end thereof, and
   a cooling water pump having a cooling water pump drive shaft in parallel to said group of rotary shafts, wherein said cooling water pump is disposed in the vicinity of the other side ends of said group of rotary shafts, and said cooling water pump drive shaft engages with said third balancer gear.

4. A single inclined cylinder engine as set forth in claim 3, further comprising:

   a centrifugal governor weight provided around said pump drive shaft of said lubricating oil pump in said crank case;
   a governor lever made to swing according to the motion of said centrifugal governor weight, wherein said governor lever is vertically disposed between said centrifugal governor weight and said cooling water pump in said crank case, and
   a fuel injection pump having a member for adjusting a quantity of injected fuel, said member being connected with an upper free end of said governor lever, wherein a fulcrum of said governor lever is disposed below said lubricating oil pump drive shaft.

5. A single inclined cylinder engine comprising:

   a crank case;
   a horizontal crank shaft disposed in said crank case;
   a inclined cylinder provided on said crank case, and
   rotary shafts disposed in said crank case in parallel to said crank shaft , said rotary shafts including at least a balancer shaft, a cam shaft and a governor driving shaft, wherein axes of said balancer shaft, said cam shaft and said governor driving shaft are disposed below an

axis of said cylinder.

6. A single inclined cylinder engine comprising:

a crank case having an opening at one side surface thereof;
a side cover covering said opening of said crank case;
a crank room formed in said crank case and said side cover;
a horizontal crank shaft disposed in said crank room, wherein said crank shaft is journalled by said side cover and by a side portion of said crank case opposed to said side cover;
a cylinder disposed vertically slantwise in one of both lateral directions when viewed along an axis of said crank shaft ;
an oil pan formed by the bottom of said crank room;
a lubricating oil passage formed within a wall of either said crank case or said side cover, and
a plurality of lubricating oil inlet ports connecting with said lubricating oil passage, said plurality of lubricating oil inlet ports being open at the side surface of said oil pan constituted by either said crank case or said side cover, wherein at least one of said plurality of lubricating oil inlet ports can be chosen in correspondence to the angle of said inclined cylinder from the vertical when said engine is mounted.

7. A single inclined cylinder engine comprising:

a crank case having an opening at one side surface thereof;
a side cover covering said opening of said crank case;
a crank room formed in said crank case and said side cover;
a crank shaft and a cam shaft disposed in said crank room, wherein said crank shaft and said cam shaft are journalled by said side cover and by a side portion of said crank case opposed to said side cover;
a inclined cylinder provided on said crank case;
a lubrication hole bored in either said crank case or said side cover for supplying said crank shaft with lubricating oil, and
attaching holes bored in either said crank case or said side cover for attaching a fuel injection pump and a fuel feed pump thereto, wherein said lubrication hole and said attaching holes are in parallel and cross an axis of said cam shaft or an extension of said axis.

8. A single inclined cylinder engine comprising:

a crank case having an opening at one side surface thereof;
a side cover covering said opening of said crank case;
a crank room formed in said crank case and said side cover;
a cam shaft laterally disposed in said crank room, said cam shaft being journalled by said side cover and by a side portion of said crank case opposed to said side cover;
a inclined cylinder provided on said crank case;
a lubricating oil pump provided on either said crank case or said side cover;
an oil hole bored in either said crank case or said side cover, said oil hole being connected with a discharge port of said lubricating oil pump, and
a pressure relief hole branching from said oil hole, wherein said pressure relief hole is open toward the vicinity of a journal portion of said cam shaft.

9. A single inclined cylinder engine comprising:

a crank case having an opening at one side surface thereof;
a side cover covering said opening of said crank case;
a crank shaft substantially horizontally disposed in said crank case, said crank shaft being journalled by said side cover and by a side portion of said crank case opposed to said side cover;
a crank shaft substantially horizontally disposed in said crank case, said crank shaft being journalled by said side cover and by a side portion of said crank case opposed to said side cover;
a crank gear fixedly provided on said crank shaft ;
a balancer shaft journalled by said side cover and by a side portion of said crank case opposed to said side cover;
a balancer gear fixedly provided on said balancer shaft, said balancer gear directly engaging with said crank gear;
an inclined cylinder provided on said crank case, and
a flywheel provided on one end of said crank shaft, wherein one end of said balancer shaft in opposite to said flywheel projects outwardly from an engine body.

10. A single inclined cylinder engine comprising:

a crank case having an opening at one side surface thereof;
a side cover covering said opening of said crank case;

a crank shaft substantially horizontally disposed in said crank case, said crank shaft being journalled by said side cover and by a side portion of said crank case opposed to said side cover;
an inclined cylinder provided on said crank case;
a flywheel provided on one end of said crank shaft adjacently to said side cover, and
a flywheel housing containing said flywheel, wherein said flywheel housing is integrally formed by said side cover.

11. A single inclined cylinder engine comprising:

a crank case;
an inclined cylinder provided on said crank case;
a crank shaft; crank shaft is disposed horizontally;
a fan case disposed on said one end of said crank shaft for covering said cooling fan, wherein said fan case is disposed substantially vertically between said cooling fan and said radiator, and constitutes at its interior a volute guide for introducing the cooling wind from the whole of area surrounding said cooling fan.

12. A single inclined cylinder engine as set forth in claim 11, further comprising:

a vertically elongated fuel tank disposed along the outside surface of said crank case in opposite to said inclined cylinder when viewed along said crank shaft.

13. A single inclined cylinder engine as set forth in claim 12, wherein said fan case is partly cut away so as to provide an opening, and a part of said fuel tank is disposed along said opening, so that said fan case and said part of said fuel tank constitute a volute guide for guiding the cooling wind from said cooling fan to said radiator.

14. A single inclined cylinder engine as set forth in claim 12, wherein a cap provided on a refueling opening of said fuel tank is disposed above said radiator.

15. A single inclined cylinder engine as set forth in claim 12, further comprising:

a foot member fixed on a side surface of said crank case, wherein a lower portion of said fuel tank is attached to either said crank case or said foot member through a vibration isolator, and
an engaging member erected on said crank case, wherein an upper portion of said fuel tank engages with said engaging member, and a vibration isolator is interposed between said upper portion of said fuel tank and said engaging member.

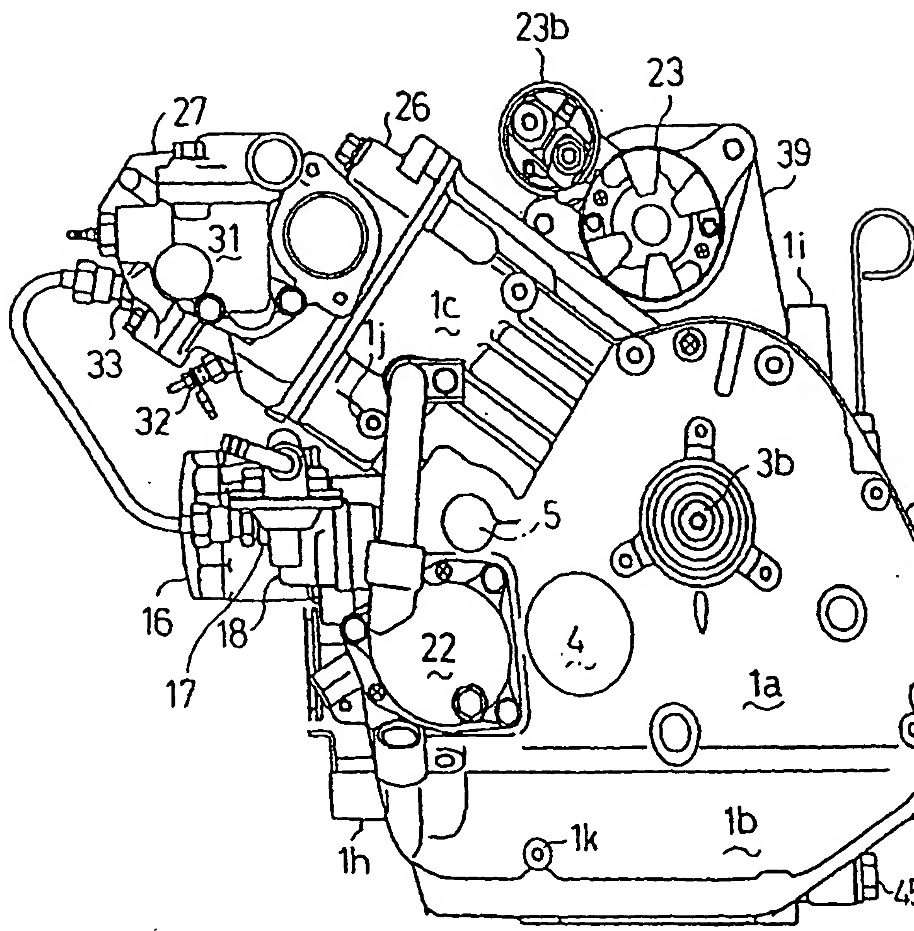
16. A single inclined cylinder engine as set forth in claim 11, further comprising:

a radiator cover continuously connected with said fan case, wherein said radiator cover is also used as a cooling wind duct.

17. A single inclined cylinder engine as set forth in claim 11, further comprising:

a cylinder head provided on said inclined cylinder ;
a muffler disposed above said cylinder head on a side of said radiator, and
an air cleaner disposed below said muffler on a side of said fan case.

FIG.1



23b
23
27
26
39
31
1i
1c
33
1j
32
3b
1
5
1h
16
18
17
22
4
1a
1b
1k
1h
1h
45

FIG. 2

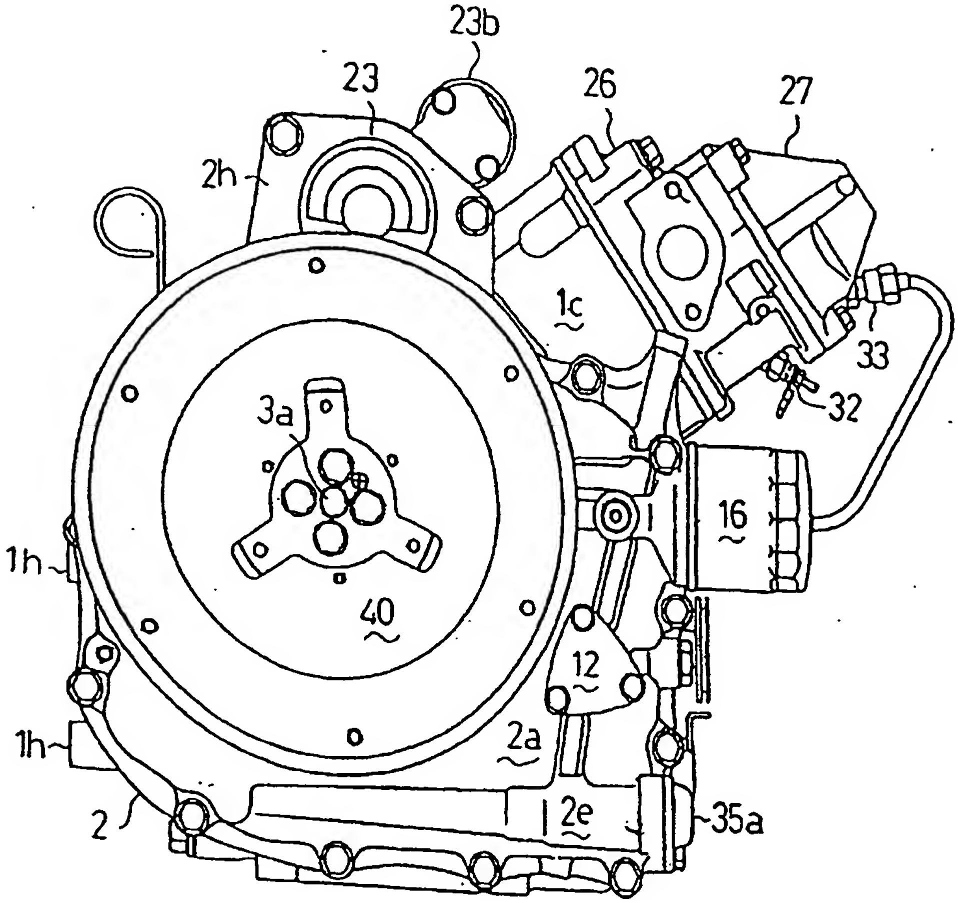


FIG.3

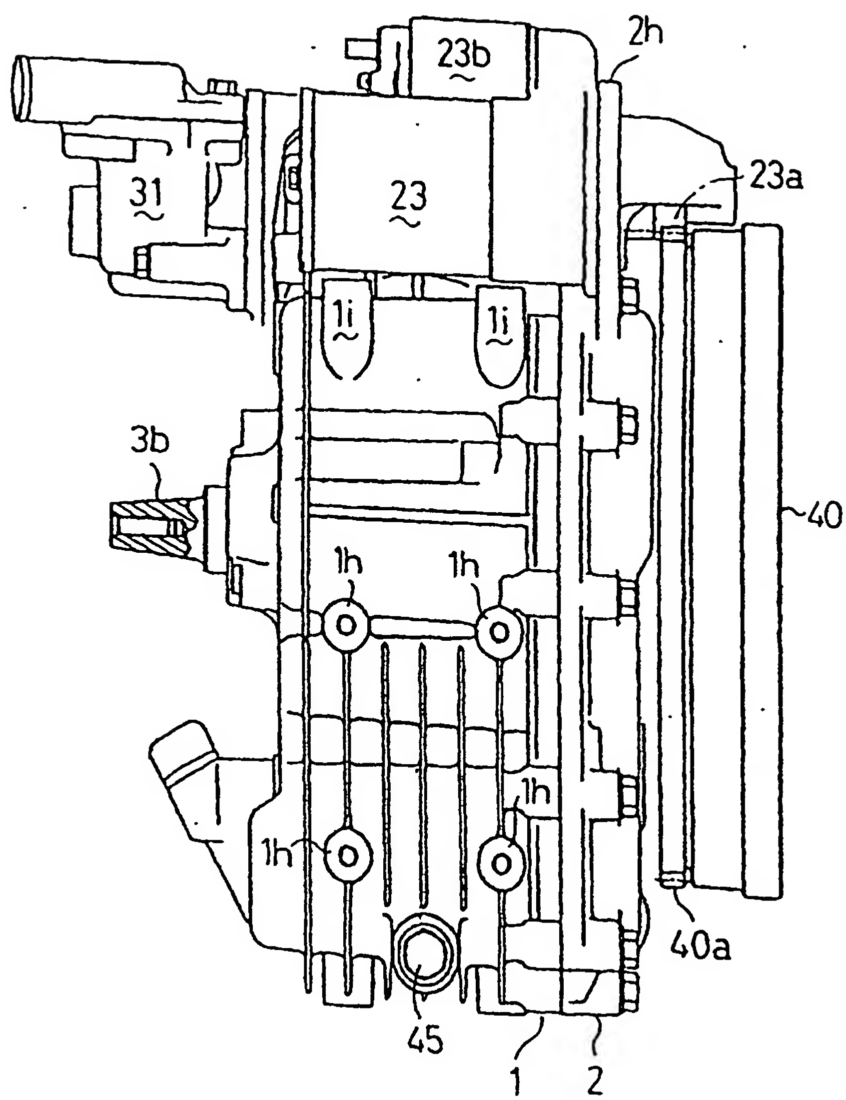


FIG. 4

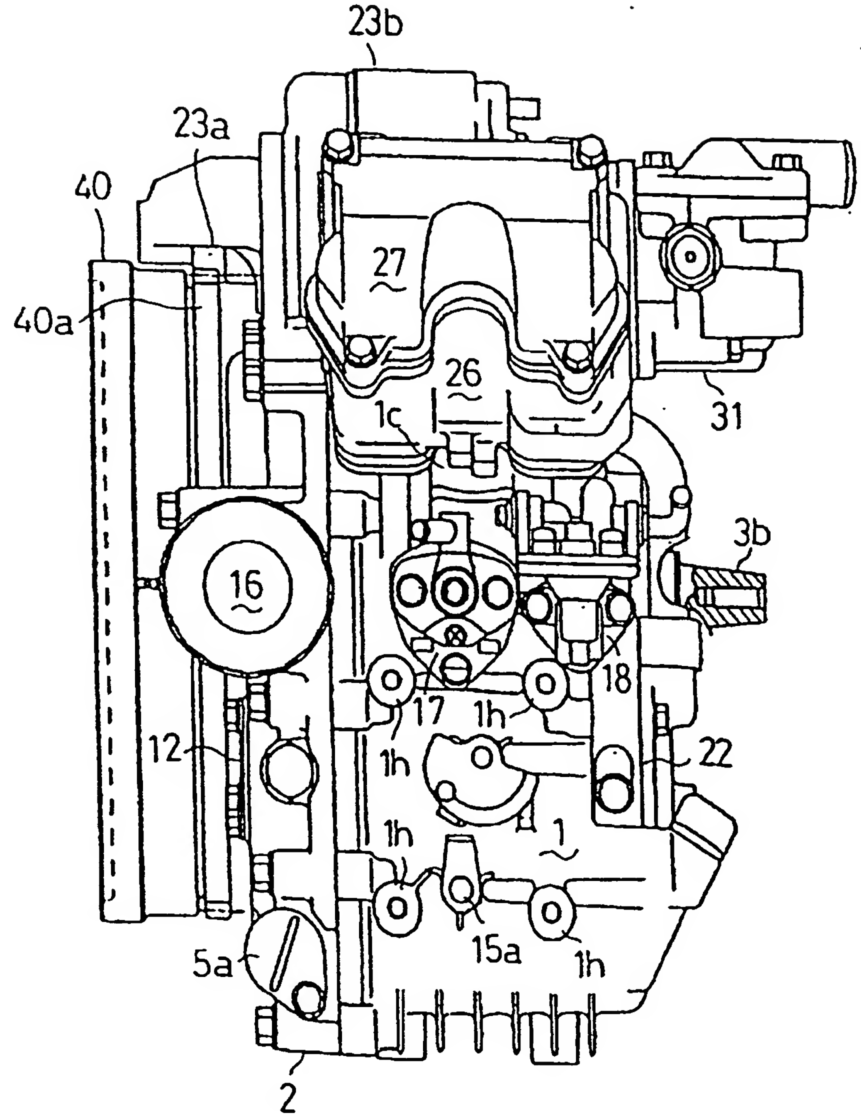
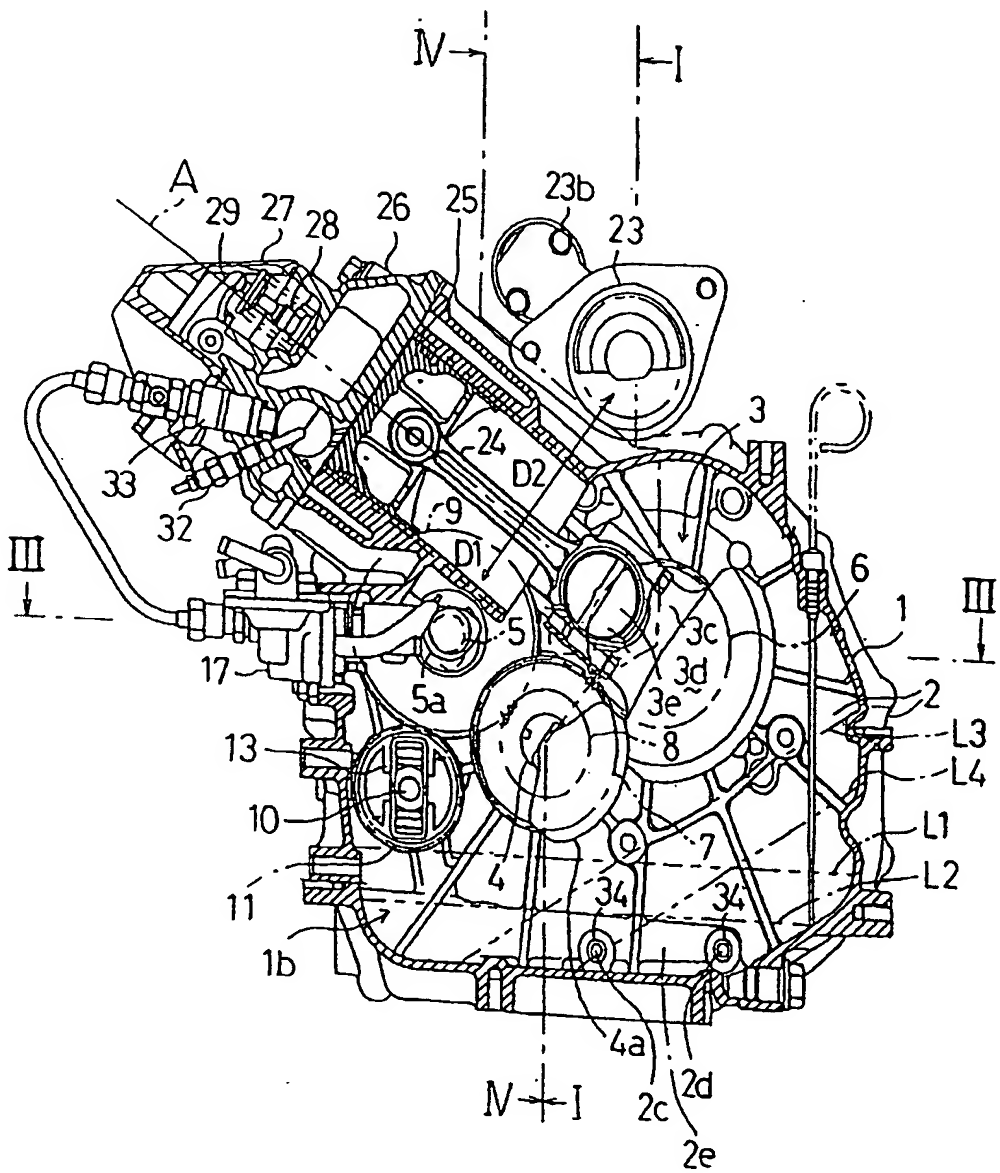

23b
23a
40
40a
27
26
1c
31
3b
16
17
18
1h
1h
12
1h
22
1h
1
1h
15a
5a
1h
2

FIG. 5



A
29
27
28
26
25
23b
23
3
24
D2
33
32
9
D1
III
6
1
III
5
3c
3d
17
5a
3e
2
L3
13
8
L4
10
L1
7
4
L2
11
34
34
1b
4a
2d
2c
2e
IV
I
IV
I

FIG.6

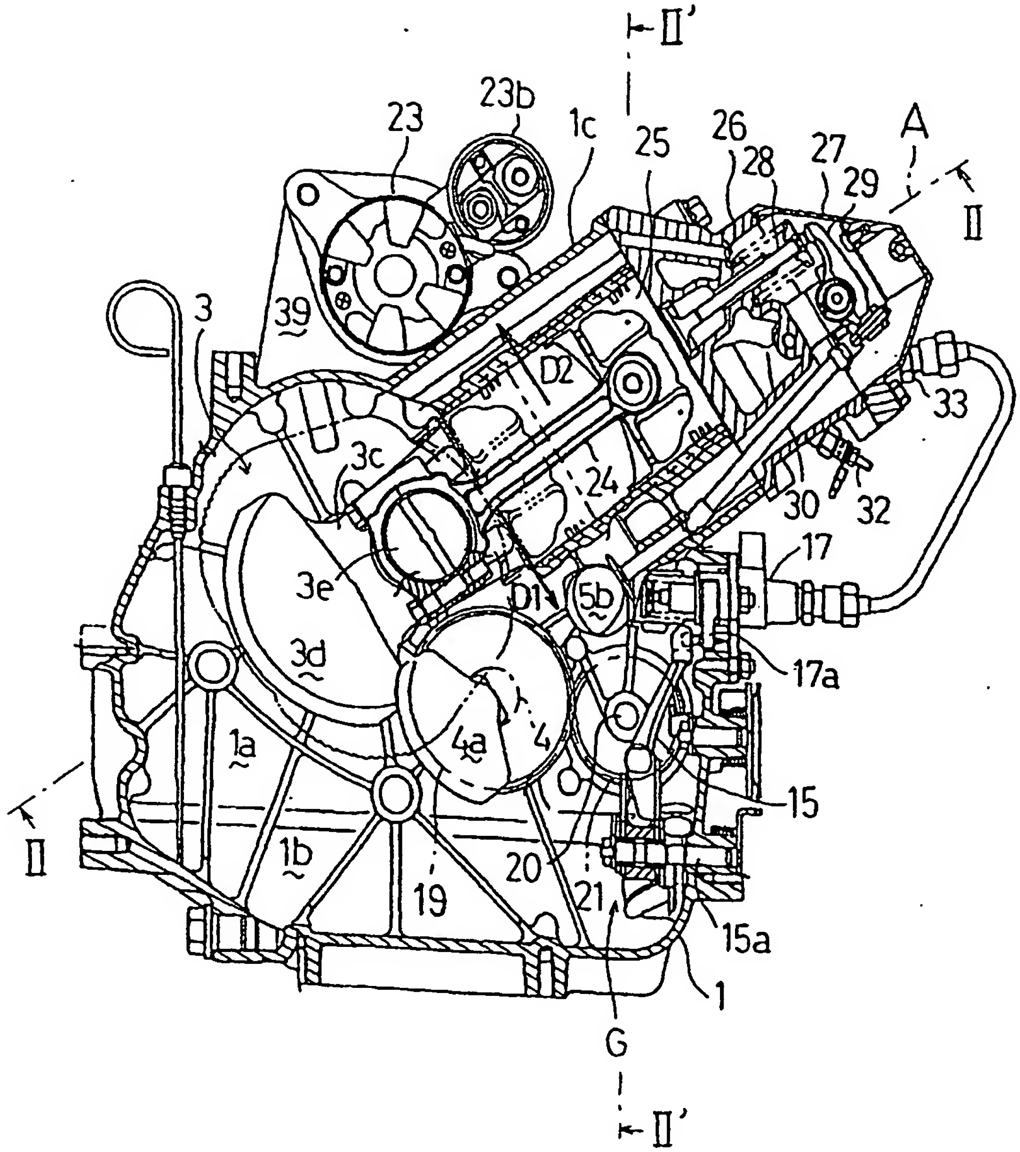

II'
23b
23
1c
25
26
28
27
29
A
II
3
39
D2
33
3c
24
30
32
17
3e
D1
5b
17a
3d
1a
4a
4
15
II
1b
19
20
21
15a
1
G
II'

FIG. 7

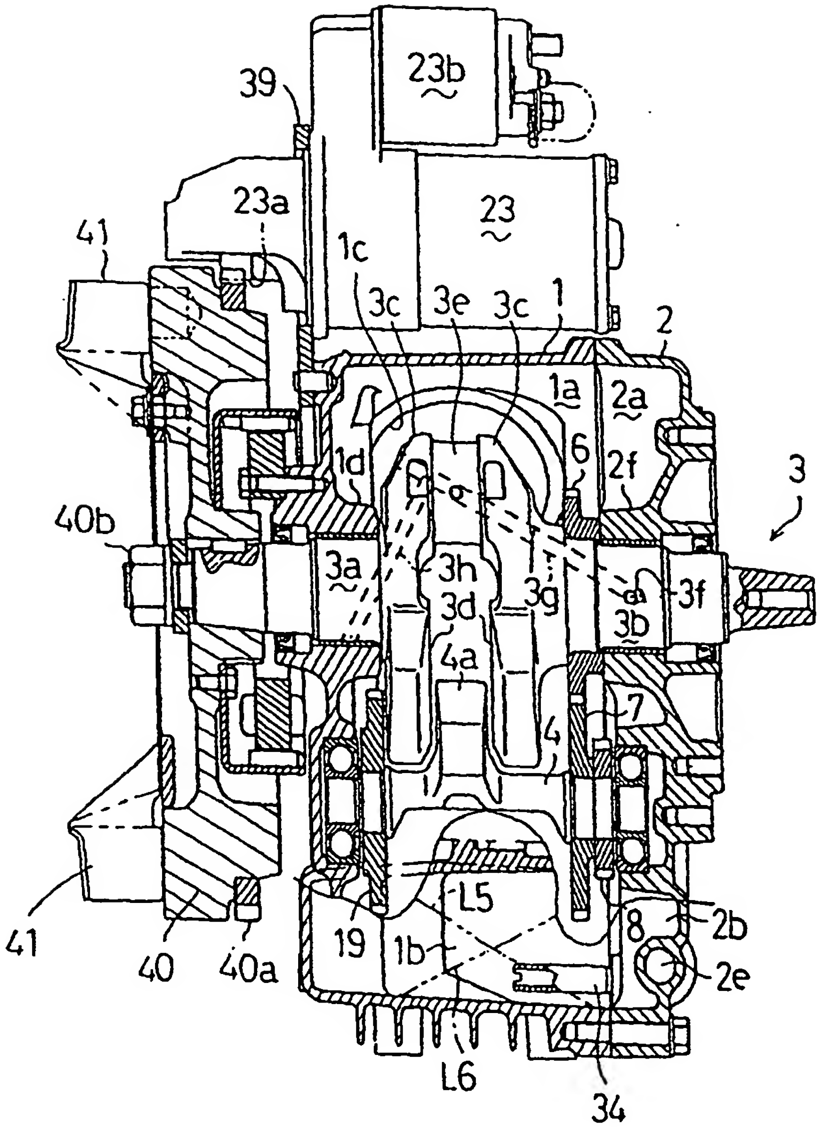

23b
39
23a
23
41
1c
3c
3e
3c
1
2
1a
2a
1d
6
2f
3
40b
3a
3h
3g
3f
3d
3b
4a
7
4
L5
8
2b
41
40
40a
19
1b
2e
L6
34

FIG. 8

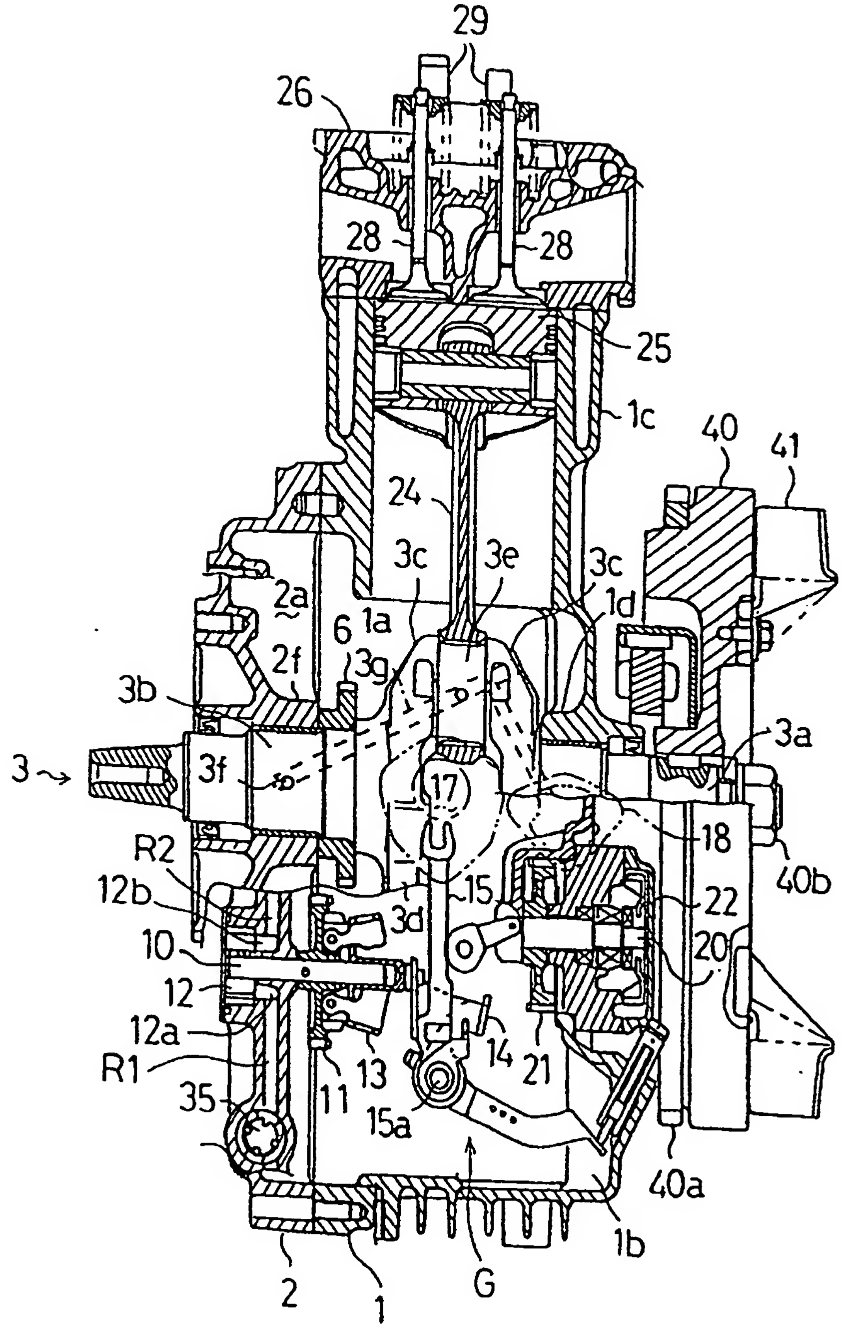

29
26
28
28
25
1c
40
41
24
3c
3e
3c
2a
1d
1a
6
2f
3g
3b
3a
3
3f
17
18
40b
R2
15
22
12b
3d
10
20
12
12a
14
21
R1
13
11
35
15a
40a
1b
2
1
G

FIG. 9

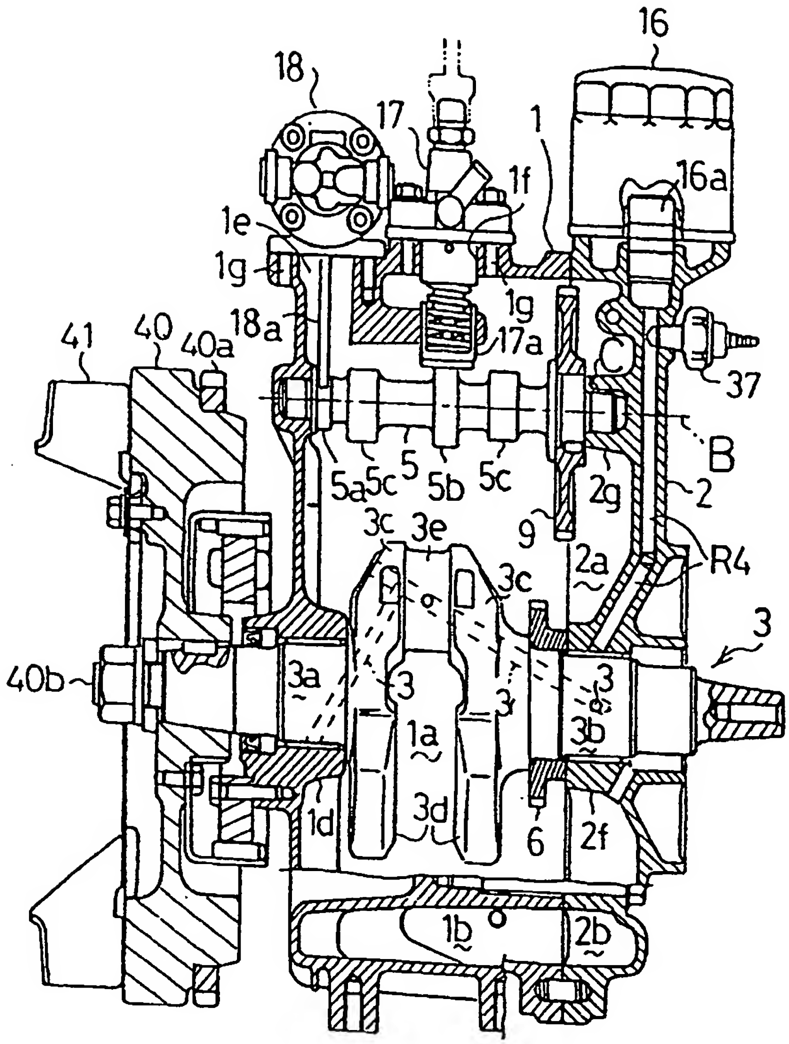
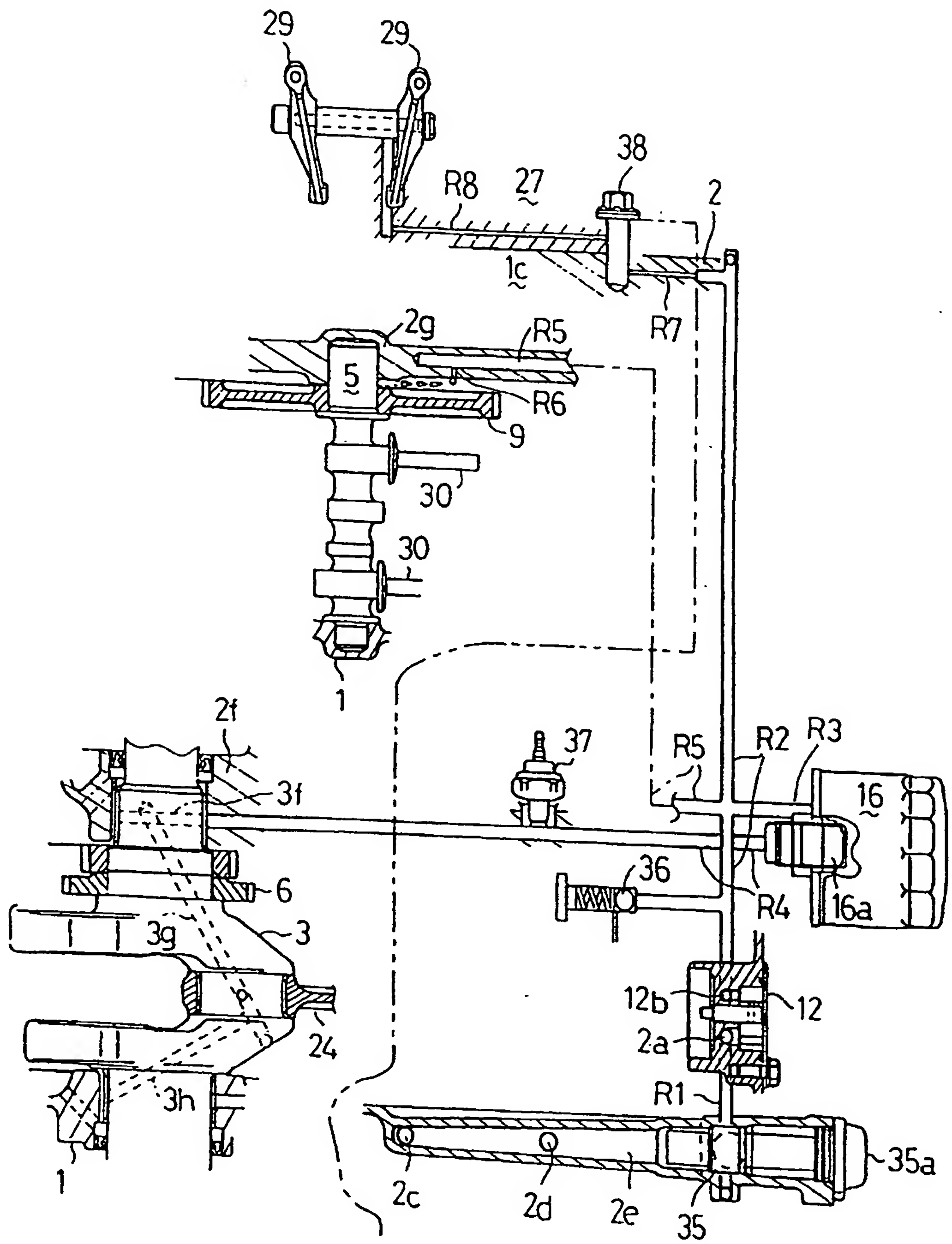

16
18
17
1
1f
16a
1e
1g
1g
18a
17a
41
40
40a
C
37
B
5a
5c
5
5b
5c
2g
2
9
3c
3e
2a
R4
3c
3
40b
3a
3
3
3
3b
1a
1d
3d
6
2f
1b
2b

FIG.10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29
38
R8
27
2
1c
R7
2g
R5
5
R6
9
30
30
1
2f
37
R5
R2
R3
3f
16
6
36
R4
16a
3
3g
12b
12
2a
24
R1
3h
1
35a
2c
2d
2e
35

FIG.11

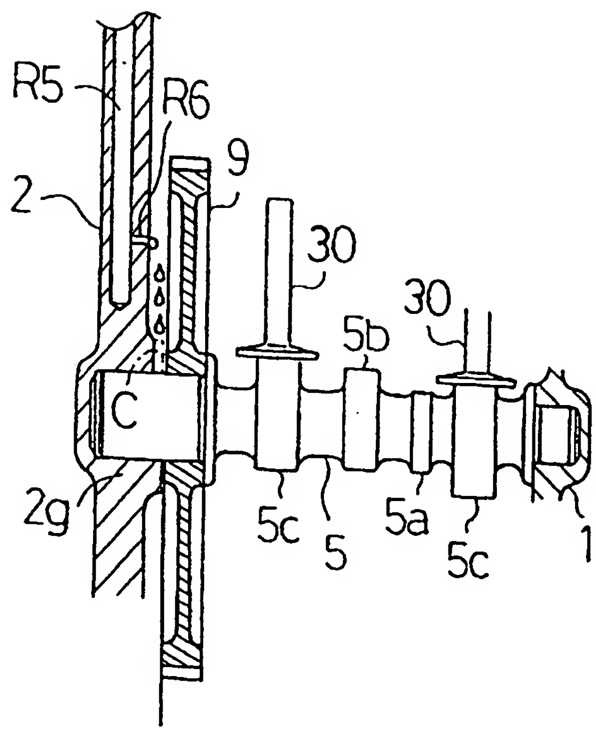


FIG. 12

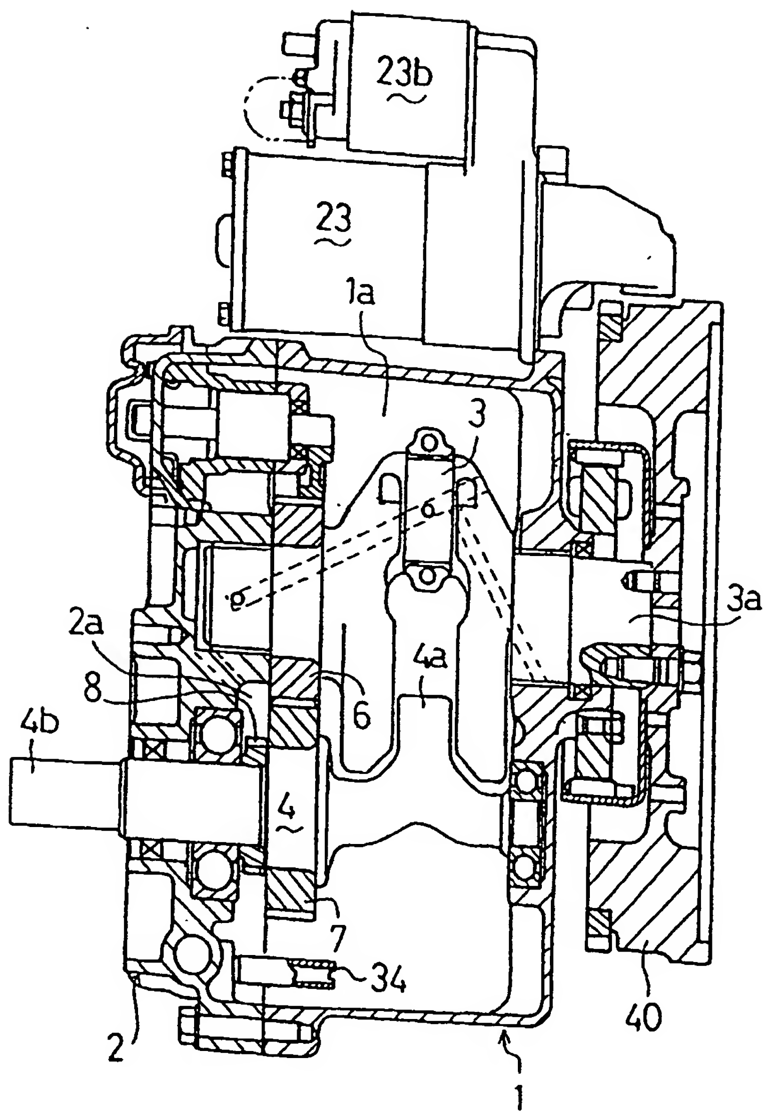


FIG.13

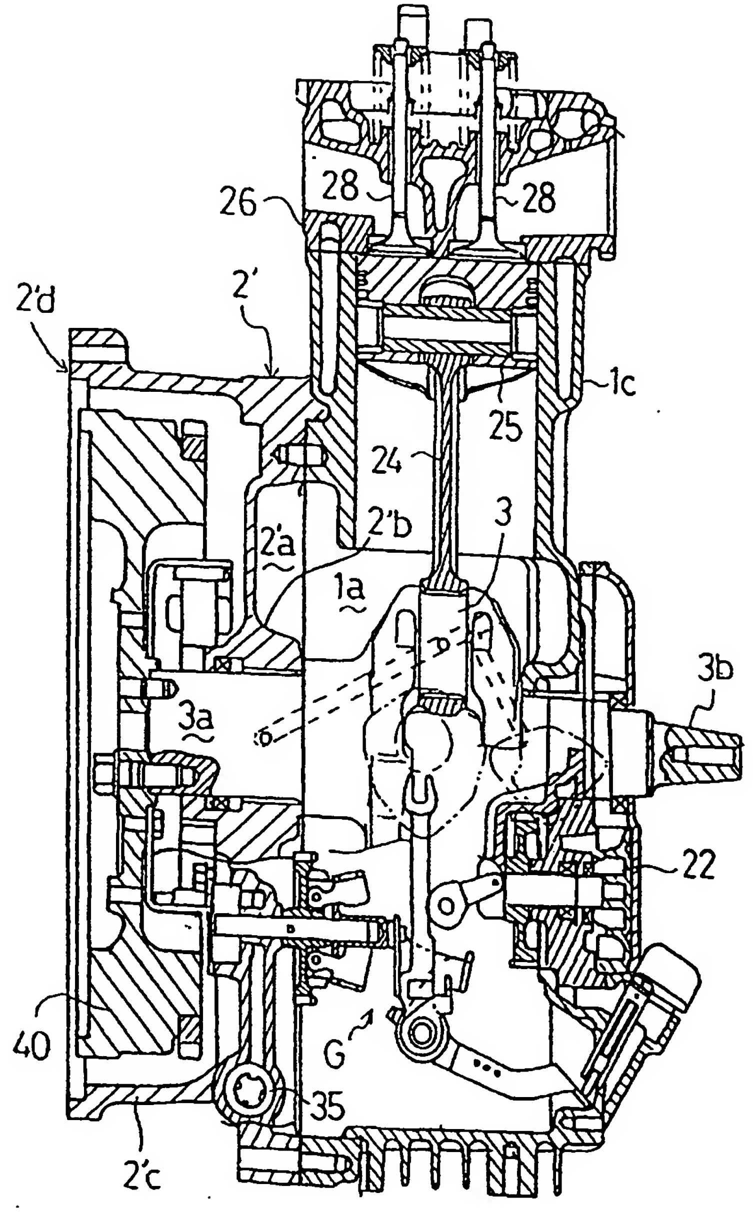


FIG.14

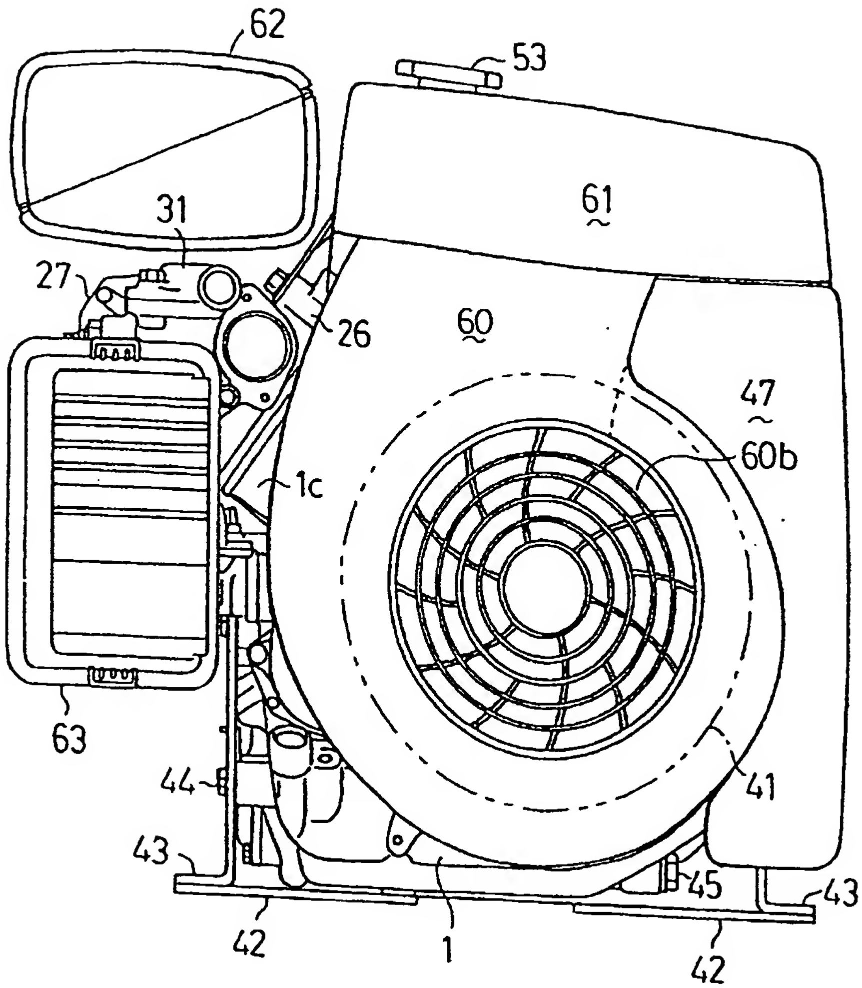
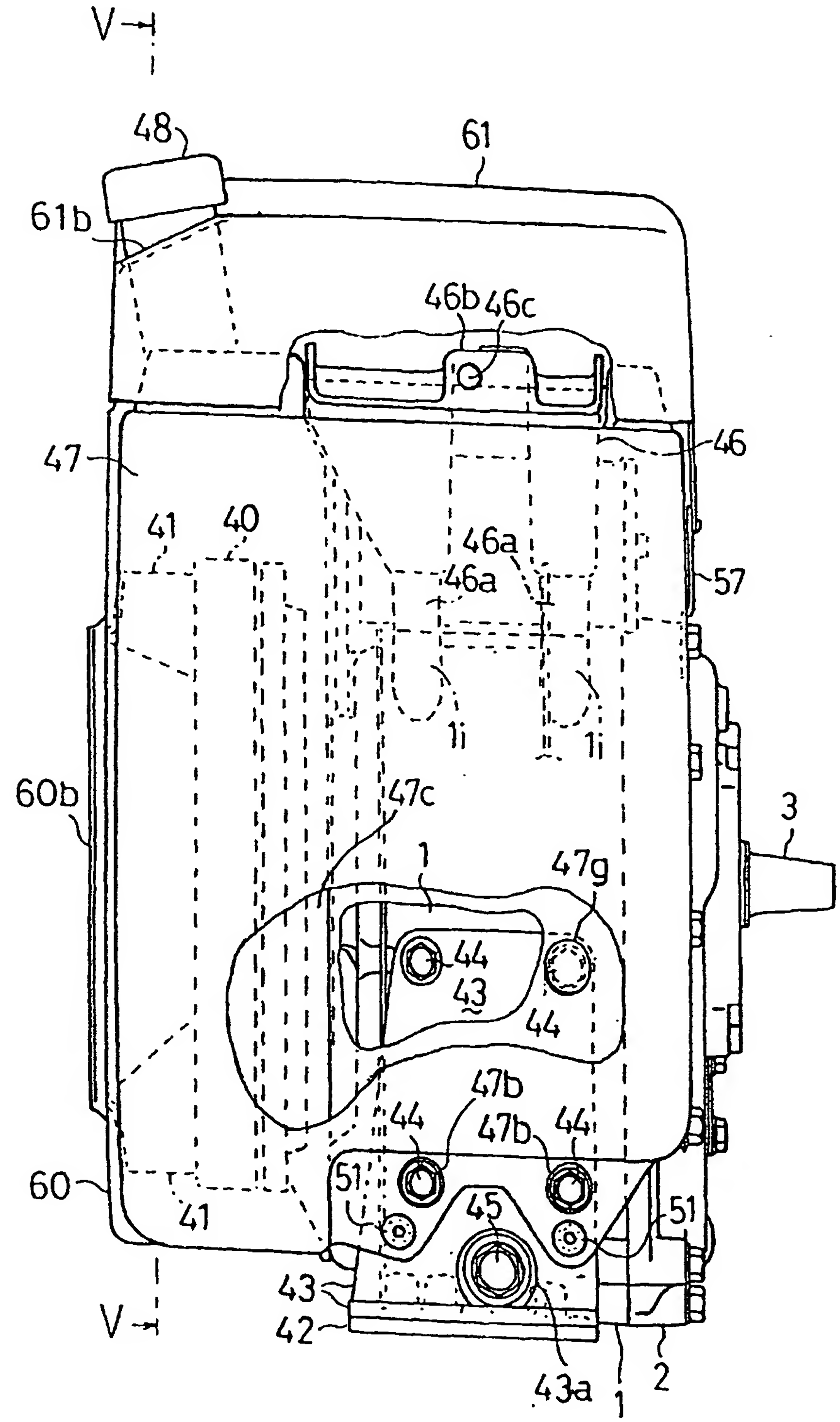


FIG. 15


V
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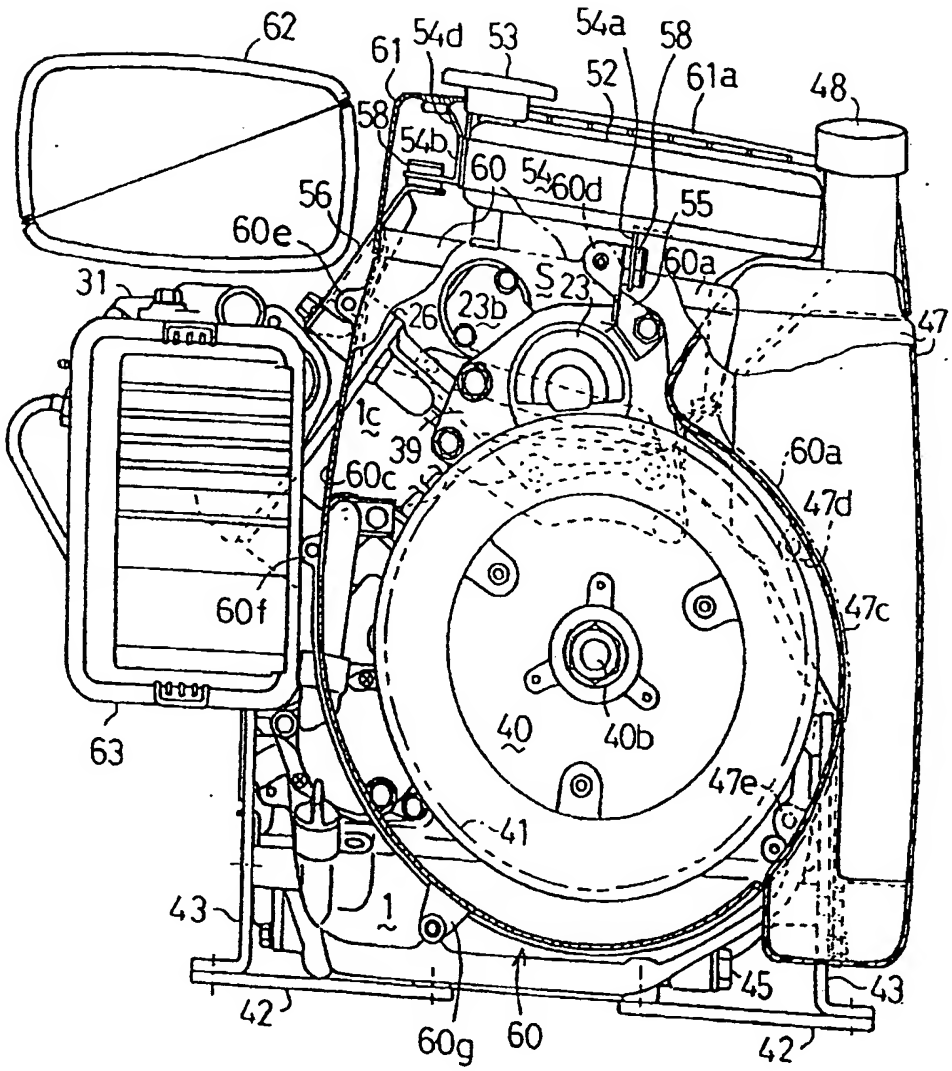
61
61b
46b
46c
47
46
41
40
46a
46a
57
1i
1i
60b
47c
3
1
47g
44
43
44
47b
44
47b
44
51
60
41
45
51
43
43
42
V
43a
1
2

FIG.16


62
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54d
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54a
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61a
48
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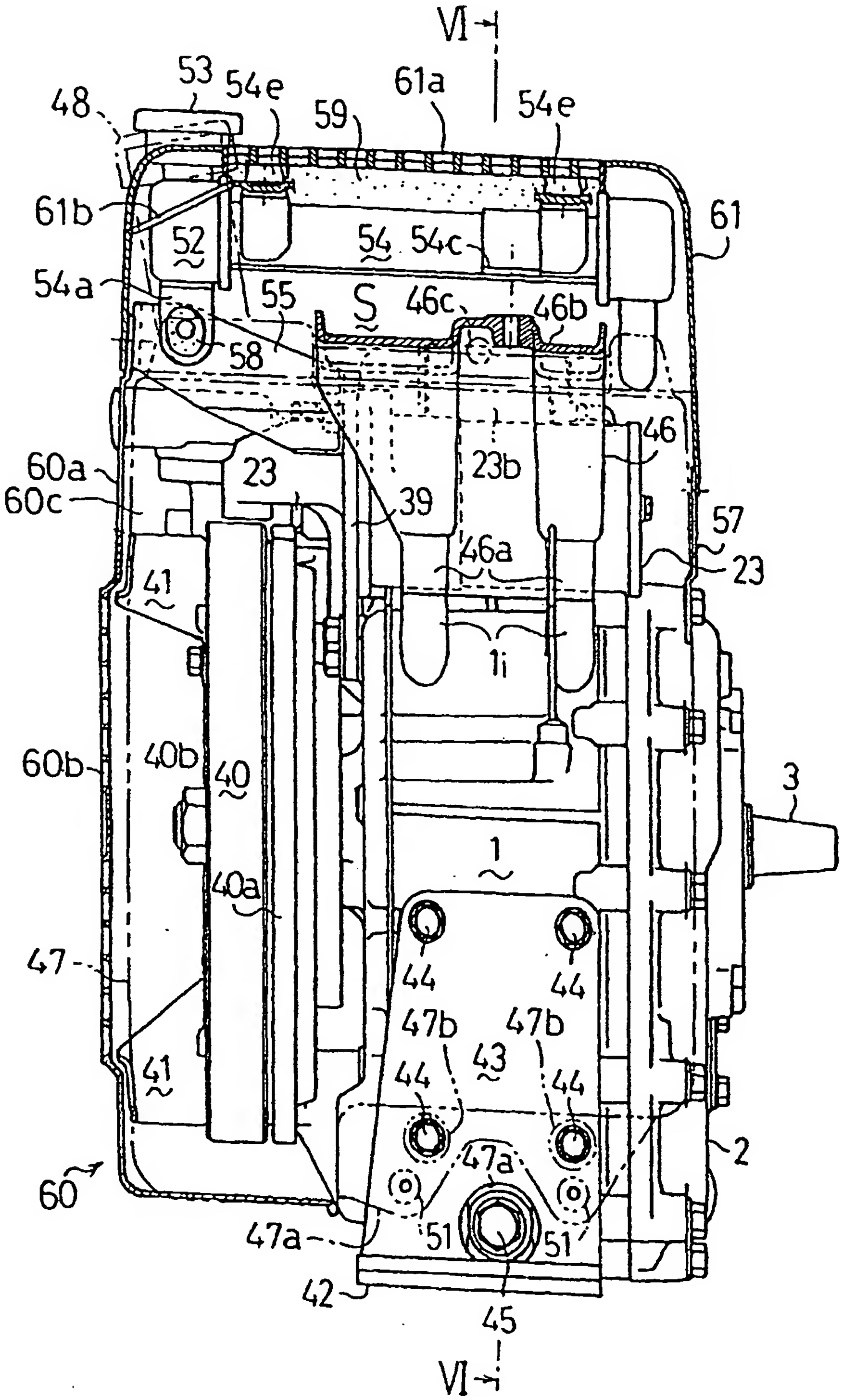
54b
60
54
60d
55
56
60e
S
23
60a
31
26
23b
47
1c
39
60a
60c
47d
60f
47c
40
40b
63
47e
41
43
1
45
43
42
60g
60
42

FIG. 17


VI
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61a
54e
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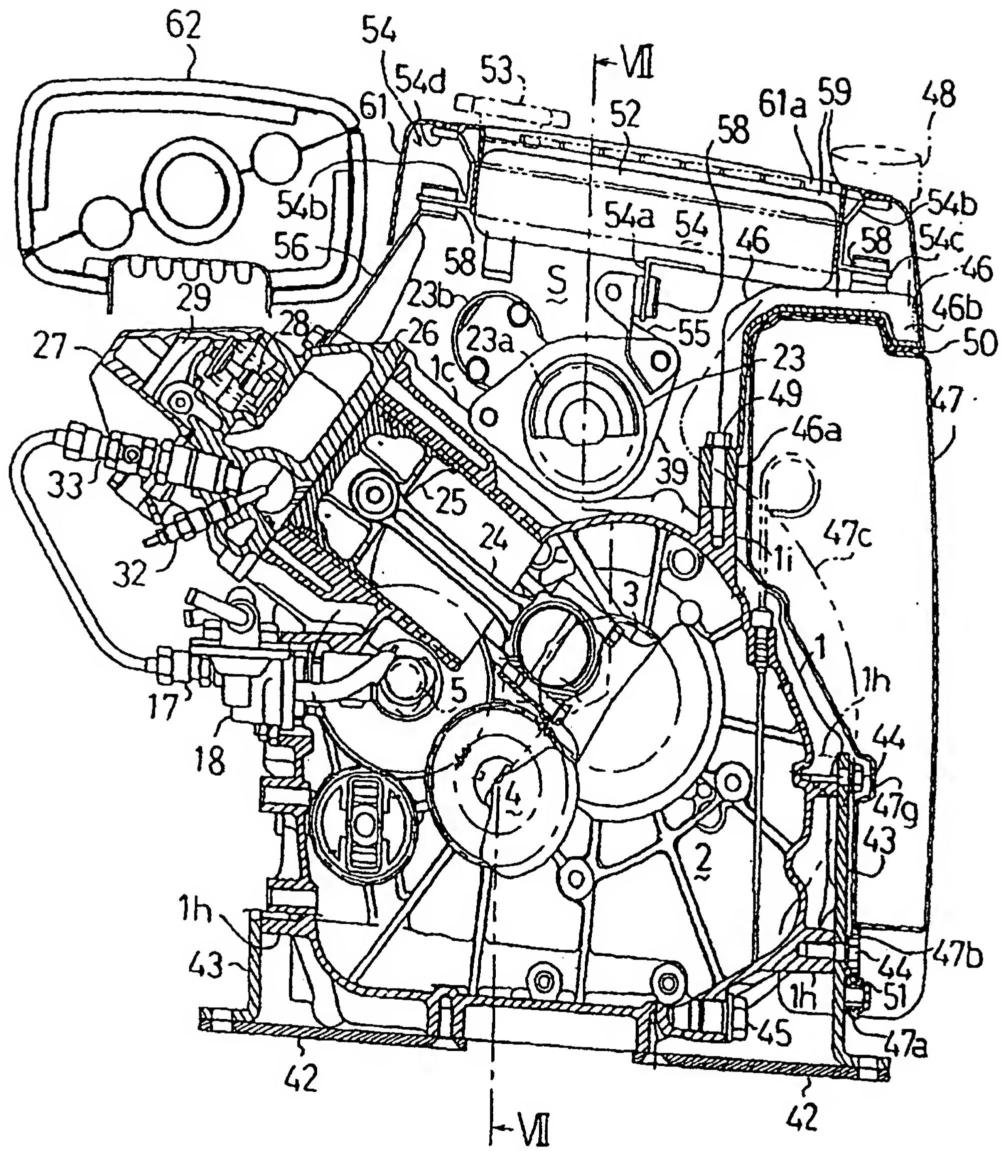
61b
61
52
54
54c
54a
55
S
46c
46b
58
46
60a
23
23b
60c
39
57
46a
23
41
1i
60b
40b
40
3
1
40a
44
44
47
47b
47b
43
44
44
41
2
47a
60
51
51
47a
42
45
VI

FIG. 18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54d
53
VII
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61a
59
48
61
58
54b
54a
54
46
54b
58
54c
56
58
S
46
46b
29
23b
55
50
27
28
26
23a
23
1c
47
49
46a
33
39
25
24
47c
32
1i
3
1
17
5
1h
18
44
4
47g
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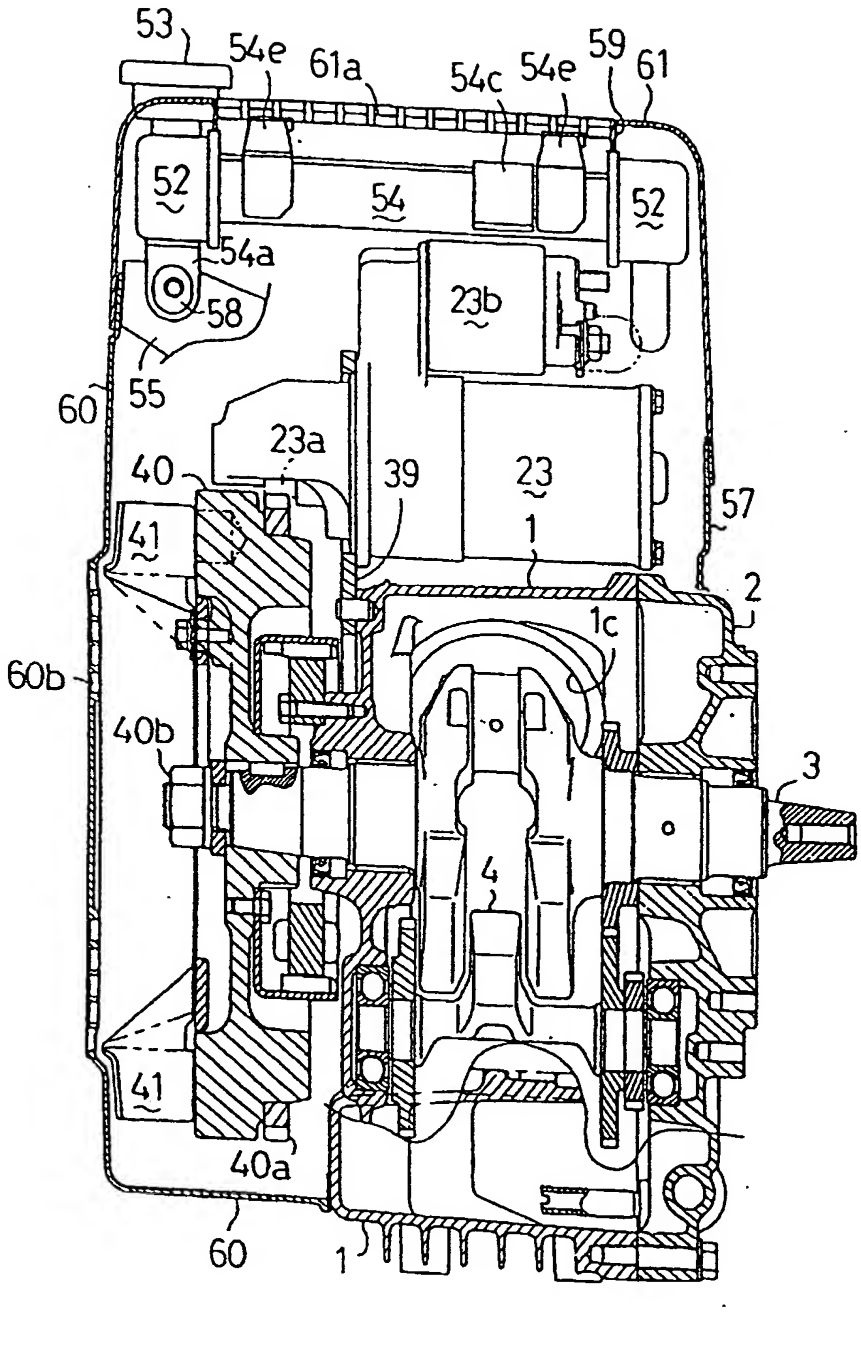
2
1h
43
44
47b
1h
51
45
47a
42
42
VII

FIG.19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54
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54a
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23b
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57
41
1
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1c
60b
40b
3
4
41
40a
60
1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/01595

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl⁶ F02B75/26, 77/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl⁶ F02B75/26, 77/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1999
Kokai Jitsuyo Shinan Koho 1971-1998

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 60-179383, A (Yamaha Motor Co., Ltd.), 13 September, 1985 (13. 09. 85) (Family: none)	1, 2, 5, 7, 9-17
Y	JP, 59-201923, A (Yamaha Motor Co., Ltd.), 15 November, 1984 (15. 11. 84) & JP, 2-548528, B	1, 2, 5, 7, 9-17
A	JP, 2-212641, A (Honda Motor Co., Ltd.), 23 August, 1990 (23. 08. 90) (Family: none)	7
A	JP, 4-84731, U (Yanmar Diesel Engine Co., Ltd.), 23 July, 1992 (23. 07. 92) (Family: none)	9
A	JP, 60-26348, U (Kawasaki Heavy Industries,Ltd.), 22 February, 1985 (22. 02. 85) (Family: none)	10
A	JP, 2-163409, A (Kubota, Ltd.), 22 June, 1990 (22. 06. 90) (Family: none)	11-17

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 July, 1999 (27. 07. 99)	10 August, 1999 (10. 08. 99)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)